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TRACE-D USERS' MANUAL

JULY 1969

S. G. Santarelli

Prepared for

DIRECTORATE OF PLANNING AND TECHNOLOGY

ELECTRONIC SYSTEMS DIVISION

AIR FORCE SYSTEMS COMMAND

UNITED STATES AIR FORCE

L. G. Hanscom Field, Bedford, Massachusetts



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Project 7070

Prepared by

THE MITRE CORPORATION

Bedford, Massachusetts

Contract F19628-68-C-0365

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FOREWORD

This report was prepared by The MITRE Corporation for the Directorate of Planning and Technology, Electronic Systems Division, Air Force Systems Command, L.G. Hanscom Field, Bedford, Massachusetts, under Contract F19628-68-C-0365.

REVIEW AND APPROVAL

Publication of this technical report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

ANTHONY P. TRUNFIO
Technical Advisor
Development Engineering Division
Directorate of Planning and Technology

ABSTRACT

This report describes the MITRE version of the TRACE-D program now in operation. While the primary function of TRACE-D is orbit determination, options are also available in the program for trajectory prediction and observational data generation. A functional description of these features is contained in this report along with a complete user's manual and a brief program description.

PREFACE

The program described herein is a modified version of the TRACE-D program originally developed by the Aerospace Corporation in Los Angeles. Although the modifications made were many and included conversion of the program to FORTRAN IV and STRAP, restructuring of the program logic, and the addition of minor options and features, the basic functions (i.e., orbit determination, trajectory prediction, and observational data generation) remain intact.

The people involved in various aspects of the effort, in addition to the author, were Dr. K. K. Maitra, G. M. Hyder, P. E. Shifres, and S. Schwartz. A great deal of appreciation is due to K. W. Hubbard, C. C. Tonies, and other members of the Flight Mechanic's Department of the Aerospace Corporation whose cooperation in obtaining the program and unlimited assistance throughout the task were invaluable.

This report is intended solely as a user's guide to the TRACE-D program, and therefore contains only a brief functional description of the analytics. For the reader seeking the mathematical details and arguments the ideal reference is the original document¹ issued by the Aerospace Corporation (see [1]).

¹ Material from this Aerospace document has been freely incorporated into this report wherever pertinent and is not to be taken as original.

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Section 1.

BASIC INFORMATION

1.1 Introduction

This document is intended as a user's manual and therefore does not discuss the theory and mathematical details of TRACE-D except in a functional context. Section 1 of this report presents some program history, a brief summary of the modification process, and a statement of the program's present status. Section 2 specifies the functional capabilities of TRACE-D while Sections 3 and 4 describe input and output (patterned after the original TRACE-D document) and Section 5 contains programming information. Wherever pertinent, throughout the report, material from the Aerospace documentation has been freely incorporated.

1.2 Program History

The TRACE-D orbit determination program was developed by the Aerospace Corporation as a multipurpose, flexible computational tool for application to problems in orbit analysis. A major design objective was that the program be able to provide answers to a wide range of problems relating to orbit and system design, space vehicle performance, and force model analysis. It was not and is not a "real time" program and therefore it is most effective for post-flight analysis and also for research and investigative purposes. The program has been used extensively and successfully by the staff at Aerospace in just such an environment.

TRACE-D was originally written in FORTRAN II and FAP for use on the IBM 7094 computer in the "CHAIN" multi-coreload mode of operation. About thirty-percent of the program consisted of machine language (FAP) subroutines including the numerical integration package. The status of the program at the time of its release to us was reported to be operational for all functions.

1.3 Modification Process

The primary objective of this effort was to produce a version of TRACE-D operable on the IBM 7030 computer here at MITRE. To accomplish this, two separate yet simultaneous endeavors were carried out; one being to get the original TRACE-D program to run successfully on a nearby 7094 installation, and the other the actual conversion of routines to FORTRAN IV and STRAP and the reconstruction of the program. Upon completion of this phase, the next step was the checkout and "debugging" of the 7030 version of the program. This task was greatly facilitated and accelerated by running test cases for all options with both versions (7094 and 7030) of TRACE-D and checking all results.

Having accomplished the primary objective satisfactorily, work began on minor adjustments and additions to the program. Such features as observation residual plotting, an expanded earth geopotential capability, and a dynamic constraint matrix capability for site location adjustments were implemented. At the present time the program is operational on the 7030 computer and has produced meaningful and significant results for many MITRE orbit-related problems.

Section 2.

MAJOR PROGRAM FUNCTIONS

2.1 Trajectory Prediction

Basic to all the functions of the TRACE-D program is the generation of a time history (either in a forward or backward direction; see Section 3) of the position and velocity of a space vehicle in an inertial frame of reference. However, this inertial ephemeris as well as its associated ground track and altitude history are, in many instances, of interest in themselves. Thus, these computations are performed and printed out in the trajectory prediction mode of TRACE-D.

The motion of a space vehicle is generated by numerical integration of the appropriate differential equations of motion. Using a Cowell formulation (i.e., expressing the total acceleration vector as three components in a cartesian system $(\ddot{x}, \ddot{y}, \ddot{z})$) three non-linear second-order differential equations are derived. A predictor-corrector numerical integration procedure based on "eighth-order differences" is used to obtain position (x, y, z) and velocity $(\dot{x}, \dot{y}, \dot{z})$ at any time t based on the known position and velocity at some initial time t_0 .

The total acceleration vector, mentioned above, is actually a sum of the effects of the perturbing forces that comprise the TRACE-D dynamic model. The earth geopotential effects (gravity) are included in the form of a spherical harmonic expansion with provision for zonal harmonics J_2 through J_{15} and all tesseral and sectorial terms through $J_{15}, 15$. Effects due to other bodies in the solar system (Sun, Moon, Venus, Mars, Jupiter) are computed from inverse-square law formulas and positions of the other bodies are obtained from tabulated coordinates stored on magnetic tape (planetary tape). Acceleration due to atmospheric drag is assumed to be directly proportional to the square of the velocity of the vehicle relative to the air. The atmospheric density is obtained from one of two different

model atmospheres that are incorporated into the program according to the user's choice. Instantaneous changes in the inertial velocity vector may be applied at specific times to simulate maneuvers such as orbit adjust or vehicle separation. Also, an included low-thrust acceleration term may be used to simulate thrust tailoff in cases involving large engines, long-term constant thrust, or, in some instances, leaking tanks or valves.

Although all of the above effects are programmed into the TRACE-D equations of motion, the actual model that is employed may include some, all, or none of these perturbations. The user has the option to choose the model by setting a series of indicators. The comparative listing of associated input and output quantities given in Table 1 suggests the range of potential application. Complete instructions for preparation of trajectory mode input data and a sample of a typical trajectory mode output listing are given in Sections 3 and 4.

2.2 Observation Generation

The object of the data generation function is to generate various forms of simulated measurements from a given definition of the ephemeris of a vehicle and the location of observing stations on the earth's surface. These measurements may be any of twenty different types from up to one hundred different sites and may be generated at user-specified frequencies. Both "clean" and "noisy" data are available, the latter being generated by adding noise of specified variances and biases to the "clean" measurements. Upon user request, the visibility function (i.e., the rise and set times) of a vehicle with respect to one or more stations may be obtained without printout of any intermediate data. When data is generated, it may be written on magnetic tape or punched on cards and is formatted such that it is readily available as input to the orbit determination process.

This option lends itself well to many applications, two of which are the following: studies of the effects of specific data imperfections

on orbit determination convergence behavior and the fitting of data using a different force model than that used to generate the data giving insight into the real-world problem of fitting live data with programmed (and always less than perfect) dynamic models.

Since the calculations performed for this option encompass all the calculations of the trajectory prediction mode, the input quantities include all those listed in Table 1 plus the additional information in Table 2. Available output quantities are listed in Table 2 also, but a more specific list of available data types with definitions is included in Sections 3 and 4.

2.3 Orbit Determination

Orbit determination is the primary function of the TRACE-D program and encompasses both the trajectory prediction and observation generation modes. Stated in simplest form the orbit determination problem consists of extracting information from observations (possible 20 types) of a space vehicle. The data is generally collected by a network of tracking stations on the surface of the earth. Nearly always, the information to be extracted includes the orbital elements but may include many other parameters of the dynamic model and of the tracking system.

The process of extraction in TRACE-D takes the form of a generalized least-squares differential correction procedure. More specifically, the goal is to determine values for a set of parameters (from the dynamic and/or observational model) such that the differences between the actual input measurements and corresponding values computed from the model (usually termed observation residuals) will be minimized in a least-squares sense. The solution set may be comprised of not more than one hundred parameters, of which not more than sixty may be trajectory-related parameters (i.e., initial conditions, geopotential coefficients, etc.). The amount of data that may be fitted is restricted only by the nature of the problem and not by the program.

Table 1.

Input/Output Quantities Associated with TRACE-D Trajectory Mode

Input Data		Output Data
1. Earth-model constants 2. Atmosphere model constants 3. Solar system constants		1. Satellite inertial position and velocity in rectangular and spherical coordinates
4. Units conversion factors		2. Magnitudes of geocentric-radius and inertial-velocity vectors.
5. Numerical integration-control constants		3. Latitude and longitude of sub-vehicle point
6. Epoch time		4. Altitude above earth
7. Position and velocity or orbital elements at epoch time	Items Printed Out at Regular Time Intervals	5.* Differences between two trajectories in rectangular, spherical, classical element, and orbit-plane coordinates
8. Satellite ballistic coefficient		6.* Time difference between corresponding points of two trajectories
9. Time, magnitude, and direction of velocity increments		7.* Magnitudes of distance and velocity difference vectors for two trajectories
* Associated with a trajectory differencing		

Table 1 (cont.)

Input Data	Output Data
10. Interval, amplitude, and decay rate of low thrust	8.** Partial derivatives of trajectory position with respect to differential-equation parameters
11. Table of time points where output is to occur	9.** Differences between changes in position and velocity produced by perturbing parameters and changes predicted by corresponding calculated partial derivatives
12. Parameter selection indicators	10. At time when vehicle crosses ascending node: Output Items 1 through 4 above Classical orbital elements Mean and true anomaly Nodal regression rate Rate of advance of the line of apsides Apogee and perigee radius and altitude Keplerian, anomalistic, and nodal periods
13. Tape-unit numbers for trajectory differencing	
14. Latitudes and longitudes where special printouts are to occur	
Items Printed Out at Special Time Points	
** Refer to the partial derivatives of trajectory position with respect to selected parameters.	

Table 1 (cont.)

Input Data	Output Data
15. Minor option indicators	<div data-bbox="491 1051 715 1232">Items Printed Out at Special Time Points</div> <div data-bbox="491 253 1203 1051"> <p>10. (continued)</p> <p>Revolution number (this set obtained Nodal period by simple differ- Nodal period decay encing rather Nodal regression than by formula)</p> <p>11. At time of the event</p> <p>Orbit adjust magnitude and direction Magnitude of low thrust at start and stop times and at ascending node times</p> <p>12. At the time when the flight path angle passes through ninety degrees (roughly at apogee and perigee):</p> <p>Output Items 1 through 4 above</p> <p>13. At the time when the vehicle reaches local maximum or minimum altitude (when $h = 0$):</p> <p>Output Items 1 through 4 above</p> </div>

Table 2.
Input/Output Quantities Associated with
TRACE-D Observation Generation Mode

<u>INPUT DATA</u>	<u>OUTPUT DATA</u>
1. All input listed in Table 1.	1. Computed observations
2. Site location coordinates	2. Rise-set times (per station)
3. Visibility function indicator	*3. Observation uncertainties
4. Observation types	
5. Observation frequencies	
6. Noise information	
7. Output mode (card, tape)	
8. Refraction specifications	
9. Uncertainty matrix for adBARV at epoch	

* Is the propagation and effect of input 9 above.

In fact, TRACE-D is capable of fitting observational data from six vehicles in a single orbit determination procedure. It allows for estimation of the trajectory initial conditions and drag coefficients associated with five satellites in addition to the usual parameters in a single satellite run.

The list of all possible input for the orbit determination mode is quite extensive as can be seen from Table 3. This is, of course, due to the comprehensive model programmed into TRACE-D for the purpose of wider and more varied applications. However, flexibility has not been sacrificed for completeness, so that the program is easily adaptable to either a non-real or more-real environment by simple input adjustment. The input and output capabilities of orbit determination are listed in Table 3 and described in detail in Sections 3 and 4. Table 4, which follows, is a complete list of all possible parameters that may be differentially corrected in TRACE-D.

Table 3.
Input/Output Associated with
Orbit Determination Mode

<u>INPUT</u>	<u>OUTPUT</u>
1. All input in Table 1.	1. Chronological list of all observations by satellite
2. Parameters in solution set	2. Variational equation solutions
3. Initial conditions for satellites 2-6	3. Trajectory printouts
4. Bounds for parameter correction	4. Observation partial derivatives
5. Station locations	5. Residuals
6. Data errors and biases	6. Station and observation type RMS summary
7. Data editing criterion	7. Computed and predicted RMS
8. Refraction correction indicators	8. Corrections
9. Iteration count	9. Covariance matrix
10. Constraint matrix for parameters	10. Correlation matrix
11. Observations from all vehicles	11. Solution set
12. Tape specifications	12. Tape of residuals

Table 4.
Parameter List*

1. Initial position and velocity components in either spherical, rectangular, or classical element form for up to six independent space vehicles.
2. Reciprocal of ballistic coefficients for up to six different satellites.
3. Up to six velocity increments (KICKS) for one satellite.
4. Amplitude and time constant for an exponentially decaying low thrust.
5. Zonal harmonic coefficients J_2 through J_{10} and all the sector harmonics $J_{2,1}$ through $J_{6,6}$.
6. Constant biases on all types of observations.
7. Scale factors for range and range-rate observations.
8. Time biases (i.e., biases in reported times at which observations were made).
9. Latitudes, longitudes and altitudes above sea level of observing stations.

* On any one run up to 100 of listed quantities may comprise the solution set with not more than 60 from types 1-5.

Section 3.

Usage

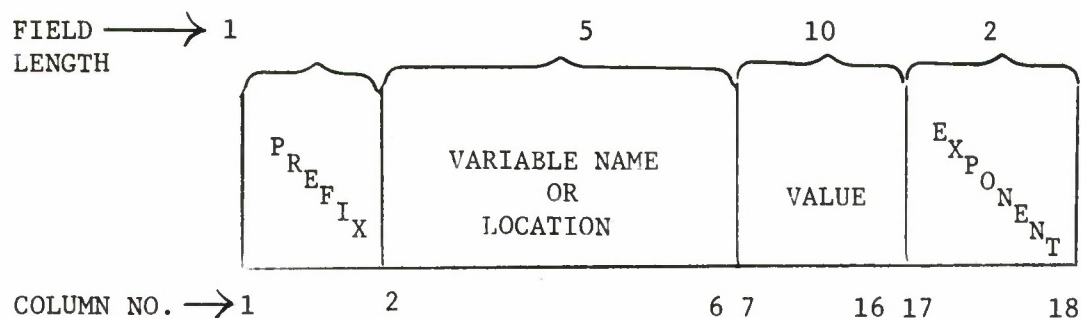
3.1 Preliminary Facts

In order to run the TRACE-D program the user need not concern himself with the internal elements of the program¹ nor worry about handling a cumbersome deck of cards. The entire program is stored on tape and can be used simply by attaching an appropriate data deck to the small basic running deck supplied by MITRE and submitting the job for execution. The basic running deck contains only tape usage information and the necessary instructions to trigger execution, therefore it is never necessary for the user to alter it in any way. Due to the varied tape requirements for each of the major functions, there are three versions of the basic running deck and the appropriate one must be used for each option exercised.

The input to the TRACE-D program falls into two categories: one which follows the normal FORTRAN IV rules of input and the other which is interpreted by a special routine in the program. The former method is used for all observing-station data (only a fraction of total input) and needs no description, while the latter method is used for all remaining input and requires a brief explanation.

The input routine accepts each piece of data from a data card in a field of eighteen columns in length with four distinct subfields as shown on the following page.

¹ The user who is curious or interested in the actual programming facts will find these concisely presented in Section 5.



1. Prefix Field - The prefix field is one column in length and can occupy columns 1, 19, 37, or 55. The mode of the input that follows is dictated by what is punched (or not punched) in the prefix field. The following are the permissible prefixes.

<u>Prefix</u>	<u>Data-Modes</u>
blank	Floating point number, number contains or implies a decimal point.
I	Fixed point number, no decimal point.
D	Hollerith information, data is not a number but a sequence of characters which can extend into the exponent field.
G	Used in connection with integration parameters, basic constants and the earth model. It indicates that card contains a symbolic name followed by a comment.
H	Followed by 1 or 2 in column 2. This is simply a header card to be printed at various places on the output. The number 1 indicates columns 1-80 and 2 indicates columns 81-132 on the printout.

2. Location Field - The location field is 5 columns in length and starts in columns 2, 20, 35 and 56. The information punched in the location field is either a symbolic name or a subscript. A symbolic

name defines a location in core where the data is stored. In the case of a subscript, it is used with respect to the immediately preceding symbolic name. Therefore, whenever a symbolic name is the name of a table, a subscript of 1 is attached to that name and those subscripts greater than 1 indicate storage relative to the start of the table. All names and subscripts should be left-adjusted within the field.

3. Value Field - The value field, 10 columns in length, starts in columns 7, 25, 43, or 61. This field together with the exponent field contains the numerical or hollerith data which is to be input. In the event the data is an integer (prefix = I) the exponent field is ignored. If the data is a floating point number (prefix column is blank, not punched) the decimal point, whenever it is not punched within the value field, is assumed to be after the last digit. Whenever hollerith data is input (prefix = D) the exponent field becomes an extension of the value field thus allowing for a total of twelve characters in the hollerith quantity. All data in the value field must be left-adjusted.
4. Exponent field - The exponent field, two columns in length, starts in columns 17, 35, 53, and 71. This field allows for a range of floating point numbers from 10^{-19} to 10^{-99} . An exponent of - 10 or smaller must start with the letter J (i.e., J0 = - 10, J5 = - 15, etc.). As in the value field the characters in the exponent field must be left-adjusted.

Although the input routine will accept four input fields per card, it is not necessary to use all four. One field used per card is just as correct since the rest of the card is ignored.

In addition to the precise field format there are a few other rules of input preparation.

1. The actual order of the data cards is almost immaterial, the only restriction being that all values with subscripts in the location field are placed in the input deck relative to the last previous symbolic name.
2. Any input which does not apply to the immediate run or is to have

a value of zero need not be specified.

3. In the case of two appearances of the same location symbol, the last one to appear defines the effective input.

4. The basic input units are feet, degrees, and seconds. Therefore, whenever the units are not stated then they are a combination of the basic set.

With the preceding basic description and the details on input preparation that follow, the user should have sufficient knowledge to use the TRACE-D program successfully.

3.2 Basic Data

The term "basic data" is defined as the data that is common to all the principal TRACE-D functions. This includes the constants for the integration procedure, the necessary physical constants, function indicator, trajectory specifications (like epoch time, initial conditions) and force model inputs.

3.2.1 Constants

The constants constitute two lengthy lists of input and involve quite a bit of keypunching. Because of this, there is available a standard set, in card deck form, which may be used as is, or altered for specific entries. This facility reduces the user's card preparation time and eliminates possibility of error.

In the event that the constants must be punched they must be formatted as shown on the following page.

3.2.1.1 Lines 1 - 19 Standard Set of Integration Constants¹

LINE #	PREFIX	NAME OR SUBSCRIPT	VALUE	EXPONENT
	Cols. 1,19,37,55	Cols. 2,20,38,56	Cols. 7,25,43,61	Cols. 17,35,53,71
1	G	INTEG		
2	I	1	1	
3	I	2	2	
2 4	I	4	1	
5	I	5	1	
6		11	1.00002516	
7		23	1.	JO
8		26	1.	
9		30	1.	
10		31	.015625	
11		32	64.	
12		33	1.	- 7
13	I	34	4	
14	I	35	1	
15	I	36	0	
16		37	.001	
17		38	0.	
18		40	2820.1763	
19	I	41	1	

¹ For definitions of the constants consult Table 5.

² Notice that there are entries missing in the INTEG list, like the 3rd one, for instance. This is because these entries are either not necessary for all options or are used by the program and not available to the user. This is true in both constants lists.

3.2.1.2 Lines 20 - 46 Standard Set Physical Constants¹

LINE #	PREFIX	NAME OR SUBSCRIPT	VALUE	EXPONENT
	Cols. 1,19,37,55	Cols. 2,20,38,56	Cols. 7,25,43,61	Cols. 17,35,53,71
20	G	C		
21		1	.43752691	- 2
22		2	.55303935	- 2
23		6	.5	
24		8	.43752691	- 2
25		9	1.	
26		13	3280.8399	
27		14	57.2957795	
28		15	20925738.	
29		16	332951.3	
30		17	.0122999	
31		18	.814979	
32		19	.107821	
33		20	317.887	
34		21	95.129	
35		22	23454.865	
36		23	3443.9336	
37		24	20925738.	
38		25	348762.3	
39		26	32.174	
40		30	348762.3	
41		31	1.5	
42		32	1.0471976	
43		33	3.14159265	
44		34	298.3	
45		35	300000.	
46		36	82505.922	

¹ For definitions of constants consult Table 5.

Table 5.

INTEG and C Constants Lists

INTEG	PARAMETERS OF THE TRAJECTORY INTEGRATION	
1	1	Formulation. 1 - Cowell (eqs. of motion), 2 - Encke (note: the Encke-T formulation is presently not available)
2	2	Differential equation subroutine. 1 - AMRK, 2 - COW
3		angle in degrees for changing mean to true equinox
4	1	Sun (4-9) are selectors for other-body perturbations
5	1	Moon If tape unit number at numb(18) is not zero,
6	0	Venus the perturbations are included or omitted
7	0	Mars according as the selector is non-zero or zero
8	0	Jupiter
9	0	Saturn
10	C(22)	Sun (10-15) are interpolation scale factors for use using contents of C(22), the number of earth-radii in an astronomical unit:
11	1.00002516	Moon
12	C(22)	Venus
13	C(22)	Mars
14	C(22)	Jupiter
15	C(22)	Saturn
16	0	Similar velocity scale factors. (not now used, and thru all zero).
21	0	
22		(used internally - Encke)
23	IE-10	E Bar, COW subroutine truncation error control para- meter.
24		(used internally - Encke)
25		(used internally - Encke)
26	1.	A, see COW writeup.
27-29		(not used)
30	1.	Initial time step size.
31	.015625	Minimum time step size (1/64)
32	64.	Maximum time step size
33	1E-7	Kepler equation convergence criterion.
34	4	Ratio of Cowell step size to Runge-Kutta step size
35	1	if 1, do not recompute perturbations for corrector. if 2, do.
36		Flag for perturbation computation (used if INTEG(35) = 1).
37	.001	Least squares convergence criterion (relative)
38	0	Least squares convergence criterion (absolute)
39		(not used)
40	2820.1763	Speed of light (earth-radii/minute)
41	1	If non-zero, round position and velocity vectors for acceleration computation. If zero, truncate

Table 5 (cont.)

INTEG	PARAMETERS OF THE TRAJECTORY INTEGRATION	
42	Reserved for later use	
C CONSTANTS		
1	.0043752691	Earth rotation rate (rad/min)
2	.0055303935	Gm, earth gravitation constant (ER**3/min**2)
3		Option for speed of light correction
4		B=1-E, relative semi-minor axis of ellipsoid (computed in CSET)
5		B**2/A**2 = (1-E)**2 (computed in CSET)
6	.5	Factor for decreasing bounds in L. S. solution
7		2*E-E**2 (computed in CSET)
8	.0043752691	Atmosphere rotation rate (rad/min)
9	1.	Earth radius
10		Input N for N-sigma residual editor
11		Input scale factor for N-sigma residual editor
12		If input non-zero, go thru 1 st iteration twice for sums
13	3280.8399	Feet/kilometer
14	57.2957795	Angle conversion factor
15	20925738.	A, earth radius in feet
16	332951.3	Relative mass of sun
17	.0122999	Moon
18	.814979	Venus
19	.107821	Mars
20	317.887	Jupiter
21	95.129	Saturn
22	23454.865	Earth-radii/astronomical unit
23	3443.9336	Nautical miles (6076.1155 ft)/earth radius
24	20925738.	I/O distance conversion factor
25	348762.3	I/O velocity conversion factor
26	32.174	Go (used for CDA/W and thrust/W)
27		Input parameter difference for trajectory differencing
28		Input threshold for percent difference for trajectory differencing
29		Constant for doppler rate
30	348762.3	Ft/sec per Er/min
31	1.5	Factor for increasing bounds in L. S. solution
32	1.0471976	Rad/min per deg/sec
33	3.14159265	PI
34	298.3	Reciprocal of E = ellipticity
35	300000.	Critical altitude (ft)
36	82505.922	Deg/day per rad/min
37-39		Direction cosines of body axis for look angle

3.2.2 Functions to be Performed

LINE #

47	D	ITIN	1234	
----	---	------	------	--

¹

Line 47 contains the ordered list of all functions to be performed during a single run. Selection of functions is governed in accordance with the following code numbers.

Code numbers

Functions

12 → Orbit Determination

3 → Trajectory Prediction

4 → Data Generation

Up to twelve functions may be selected in any one run, i.e., the program will perform twelve specified functions in one continuous machine job. The example above specifies that an orbit determination be carried out first followed by a trajectory prediction and then a data generation.

3.2.3 Trajectory Specifications

3.2.3.1 Lines 48-54 Epoch

48	I	YEAR	1963	
49	I	MNTH	6	
50	I	DAY	15	
51		TZNE	0	
52		HR	12	
53		MIN	45	
54		SEC	15.5	

¹ Please notice that the field labels are no longer specified (i.e., Prefix, Value, etc.) but they are, of course, implied by the divisions.

In the usual case, wherein the year, month, and day are input with the year positive, the X-axis is directed to the vernal equinox. Alternatively, if the year is input negative, the X-axis would be directed to the longitude of Greenwich. The hour, minute, and second entries refer to midnight of zone time. Greenwich Mean Time is Time Zone 0.

3.2.3.2 Lines 55-61 Initial Conditions

55	I	ICTYP	2	
56		IC	126.1	
57		2	31.23	
58		3	89.	
59		4	14.	
60		5	22600114	
61		6	25117.3	

Line 55 indicates which of the ten IC types (1, 2, ..., 9, 0) are entered in Lines 56 through 61. The alternative ICTYP entries are characterized as follows:

- a. IC Type 1 Earth-centered inertial cartesian coordinates ($x, y, z, \dot{x}, \dot{y}, \dot{z}$ in units of feet and feet per second) (see Section 3.1.1.1).
- b. IC Type 2 Spherical coordinates ($\alpha, \delta, \beta, A, R, v$) in units of **degrees**, feet, and feet per second (see Section 3.1.1.2). In Line 14, negative r is interpreted as height above the earth's surface in feet. In Line 15, if v is negative, circular velocity is computed and used.
- c. IC Type 3 Orbital elements ($a, e, i, \Omega, \omega, \tau$) in units of feet, degrees, and minutes (see Section 3.1.1.3).
- d. IC Type 4 Same as Item b above, with longitude λ replacing right ascension α .
- e. IC Type 5 No IC's input. The last trajectory point of the immediately preceding case is used.
- f. IC Type 6 No IC's input. The corrected initial conditions from the last previous tracking run are used.

- g. IC Type 8 Either Type 1 or 2 above, but in units of earth radii, minutes, and radians. Type number is entered at CPRAM (see Section 5.1.2.2).
- h. IC Type 9 Same as Type 1 above, but in units of earth radii and earth radii per minute.
- i. IC Type 0 No IC's input. For a tracking run, two R, A, E sets are used from the data to calculate a set of initial conditions (see Section 3.6.6).

3.2.4 Force Model Inputs

3.2.4.1 Lines 62-68 Drag and T Matrix

62		DRAG	.01	
63	I	2	1	
64		4		
65		4		
66		6	-8.6	
67		7	-55.5	
68	I	TMATX	4	

Line 62 contains the drag parameter $C_D A/W$ in square feet per pound and Line 63 contains the atmosphere model specification (ARDC 59 or Lockheed/ Jacchia). The ARDC model will be used when DRAG(2) is 0 and the Lockheed/Jacchia model when DRAG (2) is 1. If line 63 is a 1, Lines 64 and 65 contain quantities used in the Lockheed/Jacchia model.

Lines 64 and 65 contain d_1 and d_2 , respectively. These are values of certain constants in the Lockheed-Jacchia atmospheric density expressions. (Consult reference 1 for details).

An entry in Line 68, TMATX, will cause the T matrix (the 3×3 matrix describing the dependence of drag force upon vehicle position) to be used in the variational equations in accordance with the following options:

- a. T MATX = 0 T matrix is not used.
- b. T MATX = 1 Input $\partial\rho/\partial h$ is used with no earth flattening.
- c. T MATX = 2 Input $\partial\rho/\partial h$ is used with earth flattening.
- d. T MATX = 3 $\partial\rho/\partial h$ is calculated with no earth flattening.
- e. T MATX = 4 $\partial\rho/\partial h$ is calculated with earth flattening.

Also, with T MATX non-zero, Lines 66 and 67 should contain input values for $\partial\rho/\partial h$. Lines 66 and 67 contain $\partial\rho/\partial h$ for altitudes between 76 and 108 n. mi. and between 108 and 376, respectively.

It should be noted that input values for $\partial\rho/\partial h$ must be used with the ARDC 1959 model. If a variable C_D term is desired, the drag table option may be utilized. In this case, the drag parameter may be considered to consist of the product of two terms, $(C_{DA}/W) \times C'_D$, wherein C_{DA}/W is a constant which can be differentially corrected by the use of the variational equation and C'_D may be considered a function of Mach number below a certain altitude and as a function of altitude at points above that altitude. Alternatively, C'_D may be considered a function of time. In either case, use of the drag table is necessary.

When the drag table is not used, input of C_{DA}/W into the DRAG location does not change usual TRACE operation. In this case, C'_D is automatically set equal to 1. If the drag table is used, the following additional inputs are required:

- a. DRAG(10) If DRAG(10) = 0, tables not used.
If DRAG(10) = 1, Mach and altitude tables used.
If DRAG(10) = 2, time table only used.
- b. DRAG(11) Altitude above which altitude table is used and below which Mach table is used (needed if (DRAG(10) = 1).
- c. DRAG(12) = 0 Used by interpolation routine.

DRAG(13) Altitude table, or time table if
 through (35) DRAG(10) = 2 ($h_1, C_D'(h_1), h_2, C_D'(h_2)$
 $\dots, h_n, C_D'(h_n), 0, 0$, or
 $t_1, C_D'(t_1), t_2, C_D'(t_2), \dots, t_n,$
 $C_D'(t_n), 0, 0$).

d. DRAG(36) = 0 Used by interpolation routine.

DRAG(37) Mach table (stored as noted in Item c.
 through (59) above).

3.2.4.2 Lines 69-75 Other Body Perturbations

68	I	CTAPE	7	
----	---	-------	---	--

If perturbations due to other bodies in the solar system are to be included in the trajectory calculations, a planetary coordinate tape must be mounted and the logical-tape unit number 7 must be entered at CTAPE.

69	G	C		
70	I	4	1	
71	I	5	1	
72	I	6	0	
73	I	7	0	
74	I	8	0	
75	I	9	0	

Lines 69-75 contain the C constants that indicate which bodies are being considered. The six bodies corresponding to C(4) through C(9) are the Sun, Moon, Venus, Mars, Jupiter, and Saturn. Entering a 1 in C(4) implies that the Sun is to be considered, while entering a 0 in C(9) implies that Saturn is ignored. Therefore, in the example above only the Sun and Moon are used in the other-body perturbation computation.

3.2.4.3 Lines 76-79 Exponential Thrust

76		THRST		
77		2		
78		3		
79		4		

If an exponential thrust is to be used, the quantities T_1 in units of force/mass = ft/sec², T_2 in units of min⁻¹, and t_s and t_f in seconds from midnight of epoch date must be input at THRST, THRST(2), THRST(3), and THRST(4) locations, respectively.

3.2.4.4 Lines 80-96 Gravity Perturbations

80	I	IFLAG		
81	I	28	0	

Lines 80 and 81 above contain the input quantity IFLAG(28) = 0. This is an indicator that must be set in order to clear storage for the earth model that is to be specified.

82	I	IOB	10	
83	I	2	6	
84	I	3	10	
85	I	4	6	

Lines 82-85 define the number of terms to be used in the earth geopotential expansion. IOB(1) is the number of zonals and IOB(2) is the index of tesserals. Therefore, in the example above, 10 zonals will be used and tesseral terms up to and including the 6,6 term. Lines 84 and 85 specify IOB(3) and (4) which are the number of terms to be used in the V-matrix. The V-matrix is a measure of the dependence of the gravitational force upon vehicle position and is included as one of the many necessary calculations for the observation

partial derivatives (for differential correction).

If these two values are set to zero the V-matrix calculations are ignored. For a derivation of the V-matrix and its implications Appendix B of Reference 1 is recommended.

86		OBJZ		
87		2	1,826	-2
88		3	2,485	-6

Lines 86-88 specify the zonal coefficients in the following order:

OBJZ (1)	not used
(2)	J_2
(3)	J_3 etc.

89		OBJT		
90		2	1.556	-6
91		3	2.26	-6
92		4	1.72	-6
93		OBLT		
94		2	16.18	
95		3	35.62	
96		4	108.2	

Lines 89-96 specify the tesseral coefficients and the lambdas to be used, in the following order:

OBJT	J_{nm}	OBLT	τ_{nm}
(1)	J_{21}	(1)	τ_{21}
(2)	J_{22}	(2)	τ_{22}
(3)	J_{31}	(3)	τ_{31}
(4)	J_{32}	(4)	τ_{32}
(5)	J_{33}	(5)	τ_{33}
(6)	J_{41}	(6)	J_{41}
etc.		etc.	

3.2.5 Miscellaneous Inputs

3.2.5.1 Lines 97-100 Instantaneous Orbit Adjusts

97		PKICK	89020.31	
98		2	200.	
99		3	0	
100		4	62.	

Instantaneous orbit adjusts are input at PKICK. Line 97 contains t_1 (time of first orbit adjust, OA_1) in seconds from midnight of epoch; Line 98 contains K (magnitude of velocity change of OA_1) in feet per second; Line 99 contains θ (yaw angle for OA_1) in degrees, and Line 100 contains θ_p (pitch angle for OA_1) in degrees.

The TRACE-D program will accommodate up to six orbit adjusts. Additional cards may be added as necessary for OA_2 through OA_6 .

3.2.5.2 Lines 101-107 Extra Kicks

101	I	NXK	3	
102		XKICK	63456	
103		2	.2	
104		3	88721	
105		4	10.	
106		5	101018	
107		6	.02	

Up to fifty fixed orbit adjusts (i.e., instantaneous changes of the in-track velocity component) may be input at XKICK. It should be noted that these orbit adjusts are not parameters for differential correction, but are applied in the equations of motion only and are independent of the PKICK inputs. The number of extra kicks (≤ 50) is input at NXK, and the table of times and ΔV values is input beginning at XKICK. The format is time, ΔV , time, ΔV , etc., in units of seconds from midnight of epoch day and feet per second, respectively.

3.2.5.3 Line 108 Print Code

108	D	PRCDE	1	2	3	4	5	6	7	8	9	10	11	12
-----	---	-------	---	---	---	---	---	---	---	---	---	----	----	----

The print-code entry consists of two BCD words accommodating six character positions each. Entry of an X at any of these twelve positions will initiate corresponding outputs in accordance with the following:

- a. (1) Trajectory (trajectory only option).
- b. (2) Residuals (tracking only option).
- c. (3) Partial derivatives (tracking only option).
- d. (4) $A^T A$ after each iteration (tracking only option).
- e. (5) Variational equations (trajectory only option).

- f. (6) Orbital elements (trajectory only option).
- g. (7) Do not print station locations (tracking and data generation).
- h. (8) Not used.
- i. (9) Special trajectory prints¹
- j. (10) Orbital elements at ascending nodes only (trajectory only option).
- k. (11) Not used.
- l. (12) Suppress all trajectory print except ascending nodes (trajectory only option)²

3.2.5.4 Line 109 Equinox Precession Corrections

109		DALFG	.0002	
-----	--	-------	-------	--

The rotational position of the earth with respect to the inertial system is characterized by the right ascension of Greenwich at mid-night on the day of epoch (α_g) and is computed with respect to the mean equinox of epoch date. An additional factor for correcting to true equinox of epoch date optionally may be input at DALFG in units of degrees.

3.2.5.5 Lines 110-113 Direction of Integration

The TRACE-D program is capable of generating a time history of position and velocity in a forward or backward direction in any one run.

The inputs which determine this direction are INTEG(30), INTEG(31), INTEG(32). If these inputs are negative then backward integration from epoch time is assumed by the program. If positive,

¹ Prints will occur at times of maximum and minimum altitude above the oblate earth, at times when the flight-path angle equals 90 degrees and at special latitudes and longitudes if values are entered (see Section 3.3.6).

² If the option to write a binary trajectory tape (B7) has been selected, the writing of that tape is controlled by the PRTIM entries (see Section 3.3.1).

as in the standard case, forward integration from epoch is performed.

110	G	INTEG	
111	30		-1.
112	31		-.01
113			-10.

The example shown above indicates to the program that backward integration must be performed starting at epoch with an initial time step of -1. minute (see Table 5 for the explanation of INTEG constants), a minimum time step of -.01 minutes and a maximum time step of -10. minutes.

When performing any of the three basic options, these inputs may be set negative. In trajectory generation a time history back from epoch will be produced. In the observation generation mode, observations previous to epoch may be generated. In the orbit determination mode, data previous to epoch may be fit. Generally this makes TRACE-D a more flexible program by making the position of epoch and the known initial conditions less rigid.

It should be noted that both backward and forward integration can not be performed in the same run but two runs would have to be made, each with a different direction of integration.

3.2.5.6 Line 114 Primary Scratch Tape

114	I	PTAPE	4
-----	---	-------	---

PTAPE is the number of the primary scratch tape that the program requires and 4 is its only permissible value. This card must be included in every data deck.

3.3 Trajectory-Only Data

In addition to the basic data previously described, the following data is relevant to the trajectory generation.

3.3.1 Lines 1-7 Print Time Vector Option

	1	I	PRTIM		
n	2	I	2		
t_0	3		3		
Δt_1	4		4		
t_1	5		5		
Δt_2	6		6		
t_2	7		7		

The above sequence of print times is for outputs selected by PRCDE entries (Line 108, Section 3.2.5.3). As many as nine sets of print intervals may exist (Line 2). In the case of the i^{th} set, output is from t_{i-1} to t_i at intervals of Δt_i , with all times in minutes from midnight of epoch date if PRTIM = 1 or from epoch if PRTIM = 0. Additional cards may be inserted if $3 \leq n \leq 9$. It should be noted that a normal print at epoch is automatic.

3.3.2 Lines 8-15 Variational Equation Partial Derivatives

8	D	CPRAM								
9	D	DPRAM								
10	D	3								
11	D	5								
12	D	7								
13	D	9								
14	D	KPRAM								
15	D	3								

An X entered in any CPRAM, DPRAM, or KPRAM character position causes the corresponding variational equation to be solved. Printout of the partial derivatives will occur only if an X is entered at Character Position 5 in the PRCDE print code entry location. The ordering of entries in the CPRAM, DPRAM, and KPRAM character position boxes is as follows:

a. CPRAM (Initial Condition Parameters) (Line 8)

The first position specifies which one of three types of initial conditions is applicable, and succeeding positions indicate the particular parameters that are desired in each case. Ordering of CPRAM parameter entries for initial condition (IC) Types 1, 2, and 3 as shown below.

(IC
Type)

(either)	1	x	y	z	\dot{x}	\dot{y}	\dot{z}	t_0				
(or)	2	α	δ	β	A	r	v	t_0				
(or)	3	a	e	i	Ω	ω	τ	t_0				

Ordering of CPRAM IC Parameter Entries

b. DPRAM and KPRAM (Differential Equation Parameters) (Lines 9 through 15)

The ordering of DPRAM and KPRAM parameter entries is shown below, wherein T_1 and T_2 are the exponential thrust parameters and a_i , K_i , θ_{y1} , and θ_{p1} are the OA number (1, 2, ..., 6), ΔV magnitude, yaw angle, and pitch angle, respectively.

Sixty differential equation parameters is the maximum number which may be selected for any one run.

DPRAM	DRAG	μ	J ₂	J ₃	J ₄	J ₅	J ₆	J ₇	J ₈	J ₉	J ₁₀	J ₂₁
3	J ₂₂	J ₃₁	J ₃₂	J ₃₃	J ₄₁	J ₄₂	J ₄₃	J ₄₄	J ₅₁	J ₅₂	J ₅₃	J ₅₄
5	J ₅₅	J ₆₁	J ₆₂	J ₆₃	J ₆₄	J ₆₅	J ₆₆	λ_{21}	λ_{22}	λ_{31}	λ_{32}	λ_{33}
7	λ_{41}	λ_{42}	λ_{43}	λ_{44}	λ_{51}	λ_{52}	λ_{53}	λ_{54}	λ_{55}	λ_{61}	λ_{62}	λ_{63}
9	λ_{64}	λ_{65}	λ_{66}		ω_a	T ₁	T ₂					

KPRAM	a ₁	K ₁	θ_{y_1}	θ_{p_1}	a ₂	K ₂	θ_{y_2}	θ_{p_2}	a ₃	K ₃	θ_{y_3}	θ_{p_3}
3	a ₄	K ₄	θ_{y_4}	θ_{p_4}	a ₅	K ₅	θ_{y_5}	θ_{p_5}	a ₆	K ₆	θ_{y_6}	θ_{p_6}

Ordering of DPRAM and KPRAM Differential Equation Parameter Entries

3.3.3 Lines 16-18 Trajectory Comparison Options

16	I	IDIFF	1	
17	I	NTAPE	15	
18	I	DTAPE	14	

Tape units and case indicators required for the trajectory differencing function are as follows:

- a. IDIFF = 0 A regular trajectory run is indicated.
- b. IDIFF = 1 The reference trajectory will be written on the logical tape specified by NTAPE. If no entry is input at NTAPE, Logical Tape 15 will be used.
- c. IDIFF = 2 The differences between the present and reference cases are computed and written on the logical tape specified by DTAPE. If no entry is input at DTAPE, Logical Tape 14 will be used. The difference tape specified by DTAPE is rewound at the beginning of the case.
- d. IDIFF = 3 Conditions are the same as when IDIFF = 2 except that the tape specified by DTAPE is not rewound.

- e. IDIFF = 4 The tape specified by DTAPE is rewound at the beginning of the case and unloaded upon completion.
- f. IDIFF = 5 The tape specified by DTAPE is unloaded upon completion of the case.

The significance of the foregoing options is that if a single-comparison case is to be processed, IDIFF = 1 is used for the reference case and IDIFF = 4 for the perturbed case. If a series of perturbed cases are to be processed, IDIFF = 1 is used for the reference case, IDIFF = 2 for the first perturbed case, IDIFF = 3 for all intermediate cases, and IDIFF = 5 for the last perturbed case.

When this option is used, a special running deck must be obtained which defines the necessary tapes specified above.

3.3.4 Line 19 Revolution Number

19		REV	7	
----	--	-----	---	--

If an initial value other than zero is desired for the revolution number, it may be input at the REV location. This value must be re-initialized for each individual case.

3.3.5 Line 20 Trajectory Tape Generation

20	I	TTAPE	3	
----	---	-------	---	--

If TTAPE is non-zero, a binary trajectory tape will be generated on Logical Tape 19 in accordance with the following input options:

- a. TTAPE = 0 Tape will not be generated.
- b. TTAPE = 1 Tape will be rewound before generating but not unloaded after completion. This entry should be used for the first case when more than one case is involved.
- c. TTAPE = 2 Tape will not be rewound before generating and not unloaded after completion. This entry should be used for all intermediate cases.

- d. TTAPE = 3 Tape will be rewound before generating and unloaded after completion. This entry should be used when only one case is involved.
- e. TTAPE = 4 Tape will not be rewound before generating but will be unloaded after completion. This entry should be used for the last case.

This tape is not suitable for the trajectory-comparison option of the trajectory-only function.

For this option also, a special running deck containing the proper tape definitions must be used.

3.3.6 Lines 21-28 Latitude and/or Longitude Prints

n_1	21	I	LATPR	3	
	22		2	10.	
	23		3	15.	
	24		4	20.	
n_2	25	I	LONPR	3	
	26		2	200.	
	27		3	100.	
	28		4	180.	

Line 21 contains n_1 ($n_1 \leq 10$), or the number of special latitudes at which trajectory prints are requested, and Lines 22 through 24 contain the special latitudes. Additional cards may be added if $4 \leq n_1 \leq 10$.

Line 25 contains n_2 ($n_2 < 10$), or the number of special longitudes at which trajectory prints are requested, and Lines 26 through 28 contain the special longitudes. Additional cards may be added if $4 \leq n_2 \leq 10$.

Note that an X must be entered in Character Position 9 of the PRCDE entry if either of the foregoing options are selected.

This concludes the description of trajectory related data. For data deck samples and running deck setups see Section 3.6.

3.4 Observation Generation Data

The following data is pertinent only to the data generation option and is used in conjunction with the basic data (described in Section 3.3).

3.4.1 Lines 1-4 Special Output Option

1		IFLAG		
2	I	6	1	

If IFLAG(6) = 0, all generated data are printed. If IFLAG(6) = 1, rise, maximum elevation, and set times only are printed and the Data-Generation Specification Load Sheet II is not necessary except for listing of a card carrying TR in Columns 1 and 2 (see Section 3.4.5 and 3.4.6).

3	I	14		
---	---	----	--	--

If IFLAG(14) = 0, data are generated in time sequence until the available core space (bucket) is full. This output is then separated and printed by station in the same sequence as that of the input station cards. Further data are then generated until the bucket is again full, and the sort/print cycle is repeated. If IFLAG(14) = 1, data are printed as they are generated (i.e., in time sequence).

4	I	ETAPE	6	
---	---	-------	---	--

If ETAPE is non-zero, a BCD radar observation tape will be generated on the logical tape unit entered at ETAPE. The tape format will be the same as that of the tracking input data, including station locations and TF and TR cards.

3.4.2 Lines 5-23 Vehicle Attitude Specifications

y	5		YAW	1.	
p	6		PITCH	90.	
r	7		ROLL	180.	

Vehicle attitude may be specified by inputting yaw, pitch, and roll angles in degrees in the manner shown above. These entries normally are introduced in conjunction with aspect angle computations.

8		YAW		
9		811	1.	
10		812	120.	
11		813	.01	
12		814	.1	
13		815	0	
14		816	120.	
15		817	121.	
16		818	-.9	
17		819	-9.0	
18		820	0	
19		821	1420.	
20		822	1420.5	
21		823	360.	
22		824	0	
23		825	0	

The time history of vehicle attitude maneuvers may be specified by means of a table entered at YAW(811). The format of this table, which is used in connection with generation of radar aspect angles and may consist of up to three sets of five entries each, is itemized in Table 6.

The yaw-, pitch-, and roll-angle values that make up these input sets of angular rates are assumed to change at the rate given over the time interval defined by the start and stop times. Nominal orientation is zero yaw, pitch and roll which corresponds to the condition where the vehicle body axis is normal to the geocentric radius vector, the nose of the vehicle is in the in-track direction, and the top of the vehicle is in the direction of the extended radius vector.

Vehicle attitude at time of epoch and for the case where the entries in Table 6 are all zero (i.e., when nothing is input) is assumed to be the attitude specified at YAW, PITCH, and ROLL. If gaps in the time entries of the table are present, the angles are held constant at the last computed values.

Table 6.
YAW(811) TABLE FORMAT

Entry	Description
YAW(811)	Start time in minutes from epoch for first set of angular rates.
YAW(812)	Stop time in minutes from epoch for first set of angular rates.
YAW(813)	Yaw rate in degrees per minute.
YAW(814)	Pitch rate in degrees per minute.
YAW(815)	Roll rate in degrees per minute
YAW(816)	Start time in minutes from epoch for second set of angular rates.
YAW(817)	Stop time in minutes from epoch for second set of angular rates.
YAW(818)	Yaw rate in degrees per minute.
etc.	etc.

3.4.3 Lines 24-38 Data Error Inputs

24	B	NOISE	3	7	7	7	7	7	7	7	7	7	7	7	7
----	---	-------	---	---	---	---	---	---	---	---	---	---	---	---	---

If NOISE is non-zero (a positive octal number), normally distributed random noise with standard deviation and mean value specified by input at RAPAR is added to the generated data. The entry at NOISE is used to start the random-number generator.

25	M	RAPAR	05,99	
26	D	01,01	H U	A B I A S
27		04,01	.057	
28	D	01,02	A L	H B I A S
29		04,02	200.	

The RAPAR array is used to indicate bias values for measurements to be generated. Line 25 merely indicates to the program that the array is of maximum size 05,99. Lines 26 and 27 specify that for station HU and the azimuth measurements the bias value to be added is .057 degrees. Lines 28 and 29 indicate that for station AL and the height measurement computed from AL the bias value to be added is 200 feet. For additional entries the same two cards are repeated with increased subscripts.

30		SIGMA	200	
31		2	.1	
32		3	.1	
33		4	50.	
34	I	ISIG	1	
35	I	2	2	
36	I	3	3	
37	I	4	112	

Lines 30-37 contain the observation data weighting factors. For each SIGMA entry, a corresponding entry defining the sigma set and data type appears in ISIG Lines 34-37. The ISIG entries are of the form 100I + K, where I is the observation set number and K is the data type. Ten sets, corresponding to I = 0, 1, 2, ..., 9, may be entered. This selected value of I is the same as the entry in Column 5 of the station location card. (See Section 3,4,5.) The data type, K, must be one of those listed in Table 7.

In the above example, range, azimuth and elevation data would contain noise with a sigma of 200 feet, .1 degree and .1 degree respectively, while height would contain noise with a sigma of 5 feet.

38		REFR		
----	--	------	--	--

If elevation is a chosen measurement to be generated, then REFR is the input quantity that allows for elevation refraction correction. The computed elevation, E, is altered to account for refraction, using either

$$E' = E + \eta_{si} \cot E$$

if $E \geq 0.1$ radian, or

$$E' = E + \frac{1}{1000} \frac{\eta_{si} \times 10^6}{12+1000E} - \frac{80}{6+1000E}$$

if $E < 0.1$ radian and $\eta_{si} \neq 0$.

REFR contains the η_{si} term, wherein $i = 0, 1, 2, \dots, 9$. The appropriate value of i is entered on the station card in Column 6 (see Section 3.4.5). Nominally $\eta_{s0} = 3.12 \times 10^{-6}$. Rise, set, and maximum elevation values are determined from the geometric E which represents the elevation before refraction correction is applied. Additional cards may be inserted at this location if necessary.

Table 7.
Data Types for ISIG Entries

Data Type (K)	Data Description	Symbol
1	Range	R
2	Azimuth	A
3	Elevation	E
4	Topocentric right ascension	α_T
5	Topocentric declination	δ_T
6	Topocentric hour angle	HA
7	Geocentric right ascension	α_g
8	Geocentric declination	δ_g
10	Argument of latitude	u
11	Cross plane	v
12	Height	h
13	\hat{x}	\hat{x}
14	\hat{y}	\hat{y}
15	\hat{z}	\hat{z}
17	Range difference	P
18	Range difference	Q
19	Range rate	\dot{R}
20	\dot{R} difference	\dot{P}
21	\dot{R} difference	\dot{Q}

3.4.4 Lines 39-45 Orbit Covariance Matrix

39		ATAS	1.	-4
40		3	.5	-7
41		6	2.	-2
42		10	4	-2
43		15	2000.	
44		21	1.	

If observation uncertainties are to be calculated, a covariance matrix for the ADBARV elements at epoch must be input in lower triangular form at ATAS. The order of the elements is Row 1/Column 1 at ATAS(2), Row 2/Column 2 at ATAS(3).

In addition, the following input is needed.

45	D	CPRAM	2XXXXXX	
----	---	-------	---------	--

The CPRAM variable indicates to the program that the covariance matrix has been input and in the ADBARV notation. (For a more complete explanation of the CPRAM variable see Section 3.3.2).

3.4.5 Station Cards

The locations of tracking stations which are associated with the observations to be generated must be input by means of station cards carrying appropriate descriptive information.

Figure 1 on the next page shows the proper fields for the input that is described below:

- a. Station ID Columns 1 and 2 (ST).

No two stations may be identified by the same symbol. The three codes that are not permissible as station ID's are TS, TR, TF.

- b. Sigma Index Column 5

The sigma index identifies the set of observation sigmas

to be applied to data that is generated from this station (see Section 3.4.3).

- c. Type of Refractivity Correction Column 6
This indicator selects the type of refractivity correction which is to be applied to elevation readings. (This input depends on previous input. See Section 3.4.3).
- d. Latitude Columns 9-17
The latitude of the station is entered in degrees.
- e. Longitude Columns 19-27
The east longitude of the station is entered in degrees also.
- f. Altitude Columns 29-36
The altitude of the station is entered in feet.
- g. P, Q Indicators Columns 38-39 and 41-42
If P, Q, \dot{P} , \dot{Q} data (i.e., range difference and range rate difference between a master station and two slave stations) is to be generated these columns must contain the station ID's of the slave stations. Also, it is necessary to enter a station card for each slave station but columns 38-39 and 41-42 are to be left blank.

The station cards must be preceded by two cards with END in columns 1-3, and must be followed by a card with TS in columns 1-2.

3.4.6 Data Limit Specification Cards

- a. Station ID (ST) Columns 1-2
- b. Data Rate Columns 9-16
Time interval in seconds at which data for a given station are to be generated and testing interval for rise set option.
- c. Minimum Elevation Columns 18-23
The minimum elevation at which the vehicle is visible to this station.

- d. Maximum Elevation Columns 25-30

The maximum elevation at which the vehicle is visible to this station. Zero value implies a 90 degree limit.

- e. Maximum Range Columns 32-40

The maximum range in nautical miles to which the vehicle is visible. Zero value causes this test to be ignored.

- f. Start Time Columns 51-58

Start time from midnight of start date in days, hours, and minutes. Zero value implies that epoch is start time.

- g. Stop Time Columns 60-67

Stop time from midnight of start date in days, hours, and minutes.

The set of cards must follow the TS card in the deck and themselves be followed by a card with TR in the first two columns.

3.4.7 Data Type Cards

The following set of cards (which are the last in the card deck) specify the exact type of measurements to be generated from each station.

Figure 3 is a card image.

- a. Station ID Columns 1-2

- b. Observation Types Columns 7-33

An X in the appropriate column will produce specific measurements according to Table 8.

ST		Interval (sec.) *										Minimum Elevation (deg.) *			Maximum Elevation (deg.) *			Maximum Range (n mi) *										Start Time			Stop Time						
1	2	9	10	11	12	13	14	15	16	18	19	20	21	22	23	25	26	27	28	29	30	32	33	34	35	36	37	38	39	40	day	hr	min	day	hr	min	
																														60	61	62	63	64	65	66	67

NOTES

ST is the station identification code.

Start and stop times are from midnight of epoch.

If start time is 0 epoch itself is used.

An asterisk (*) following a unit value indicates that a decimal point is necessary for that quantity.

Figure 2. Data Generation Limits Card Format

Identification		NOTES	
ST	ST	ST	ST
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20
21	22	23	24
25	26	27	28
29	30	31	32
33	34	35	36
37	38	39	40
41	42	43	44
45	46	47	48
49	50	51	52
53	54	55	56
57	58	59	60
61	62	63	64
65	66	67	68
69	70	71	72
73	74	75	76
77	78	79	80
81	82	83	84
85	86	87	88
89	90	91	92
93	94	95	96
97	98	99	100

Figure 3. Data Type Card Format

STPS		MO	DAY	HR	MIN	SEC	OBSERVATION 1	OBSERVATION 2	OBSERVATION 3
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190
191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230
231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250
251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290
291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310
311	312	313	314	315	316	317	318	319	320
321	322	323	324	325	326	327	328	329	330
331	332	333	334	335	336	337	338	339	340
341	342	343	344	345	346	347	348	349	350
351	352	353	354	355	356	357	358	359	360
361	362	363	364	365	366	367	368	369	370
371	372	373	374	375	376	377	378	379	380
381	382	383	384	385	386	387	388	389	390
391	392	393	394	395	396	397	398	399	400
401	402	403	404	405	406	407	408	409	410
411	412	413	414	415	416	417	418	419	420
421	422	423	424	425	426	427	428	429	430
431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450
451	452	453	454	455	456	457	458	459	460
461	462	463	464	465	466	467	468	469	470
471	472	473	474	475	476	477	478	479	480
481	482	483	484	485	486	487	488	489	490
491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510
511	512	513	514	515	516	517	518	519	520
521	522	523	524	525	526	527	528	529	530
531	532	533	534	535	536	537	538	539	540
541	542	543	544	545	546	547	548	549	550
551	552	553	554	555	556	557	558	559	560
561	562	563	564	565	566	567	568	569	570
571	572	573	574	575	576	577	578	579	580
581	582	583	584	585	586	587	588	589	590
591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610
611	612	613	614	615	616	617	618	619	620
621	622	623	624	625	626	627	628	629	630
631	632	633	634	635	636	637	638	639	640
641	642	643	644	645	646	647	648	649	650
651	652	653	654	655	656	657	658	659	660
661	662	663	664	665	666	667	668	669	670
671	672	673	674	675	676	677	678	679	680
681	682	683	684	685	686	687	688	689	690
691	692	693	694	695	696	697	698	699	700
701	702	703	704	705	706	707	708	709	710
711	712	713	714	715	716	717	718	719	720
721	722	723	724	725	726	727	728	729	730
731	732	733	734	735	736	737	738	739	740
741	742	743	744	745	746	747	748	749	750
751	752	753	754	755	756	757	758	759	760
761	762	763	764	765	766	767	768	769	770
771	772	773	774	775	776	777	778	779	780
781	782	783	784	785	786	787	788	789	790
791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810
811	812	813	814	815	816	817	818	819	820
821	822	823	824	825	826	827	828	829	830
831	832	833	834	835	836	837	838	839	840
841	842	843	844	845	846	847	848	849	850
851	852	853	854	855	856	857	858	859	860
861	862	863	864	865	866	867	868	869	870
871	872	873	874	875	876	877	878	879	880
881	882	883	884	885	886	887	888	889	890
891	892	893	894	895	896	897	898	899	900
901	902	903	904	905	906	907	908	909	910
911	912	913	914	915	916	917	918	919	920
921	922	923	924	925	926	927	928	929	930
931	932	933	934	935	936	937	938	939	940
941	942	943	944	945	946	947	948	949	950
951	952	953	954	955	956	957	958	959	960
961	962	963	964	965	966	967	968	969	970
971	972	973	974	975	976	977	978	979	980
981	982	983	984	985	986	987	988	989	990
991	992	993	994	995	996	997	998	999	1000

Figure 4. Observation Card Format

Table 8.
Output Quantities Corresponding to
Columns 7 through 33 of Data-Generation Type Card

Column	Output Quantity	Unit
7*	Range	n mi (ft on ETAPE)
8*	Azimuth	deg
9*	Elevation	deg
10*	Range rate	ft/sec
11-14*	\dot{P} , \dot{Q} , P , Q	ft/sec, ft
15	Azimuth rate	deg/min
16	Elevation rate	deg/min
17	Range acceleration	ft/sec ²
18	Mutual visibility (Output will be a list of numbers of stations visible at output time. Stations numbered in order of input on station cards. Number of stations, 8 maximum).	
19	Geodetic latitude of vehicle	deg
20	Longitude of vehicle	deg
21	Surface range from station to subvehicle point	n mi
22*	Altitude of vehicle	n mi (ft on ETAPE)
23	Doppler rate	
24	Look angle (Angle between a vehicle axis and the station/vehicle line of sight. The direction cosines of the vehicle axis in the basic inertial system must be entered in C(37), C(38), and C(39). These quantities	deg

* These quantities are output on ETAPE

Table 8 (cont.)

Column	Output Quantity	Unit
	may be input as constant or the user may provide a subroutine (FANG) to compute the direction cosines at each output point).	
25	Observation uncertainties. (If inverse $A^T A$ matrix for initial conditions is input at ATAS, the ADBARV elements are selected as parameters, and if an X is entered in Column 25, the $[A^T A]^{-1}$ is updated to observation times and the standard deviations in the quantities R, A, E, \dot{R} , \dot{A} , \dot{E} are derived and printed. The uncertainties are only those due to the uncertainty in the ephemeris which is implied by the given $[A^T A]^{-1}$ for the epoch conditions).	Same units as observations
26	Angle kappa (K). (Angle between station line-of-sight and geocentric radius vectors).	deg
27	Aspect angles. (Angle 1 (Φ) is defined as the angle between the vehicle yaw axis and projection of the station line-of-sight vector in the roll plane. Angle 2 (Θ) is defined as the angle between the vehicle roll axis and the line-of-sight vector to the station.	deg
28	Signal attenuation = $-40 \log_{10} R$, where R is slant range in feet	db
29*	\hat{x} , \hat{y} , \hat{z} (Same rectangular earth-fixed (X through Greenwich) geocentric quantities accepted as Type 5 observations for orbit determination).	n mi (ft on ETAPE)

* These quantities are output on ETAPE

Table 8 (cont.)

Column	Output Quantity	Unit
30*	Topocentric right ascension and declination	deg
31*	Geocentric right ascension and declination	deg
32*	Topocentric hour angle	deg
33*	Vehicle-centered argument of latitude and cross-plan angle	deg

* These quantities are output on ETAPE

3.5 Orbit Determination Data

This section gives a description of all the pertinent data for a differential correction run to be used in conjunction with the previously described basic data.

3.5.1 Lines 1-14 Multiple Satellite Option

As was mentioned in Section 2, TRACE-D will accept measurements for up to six satellites on any one run. The method of specifying the input for these vehicles is shown below.

Year	1	I	SAT2	1964	
Month	2	I	2	2	
Day	3	I	3	10	
Hour	4		4	3.	
Minute	5		5	30.	
Second	6		6	52.	
ICTYP	7	I	7	2	
IC	8		8	352.	
2	9		9	10.	
3	10		10	90.05	
4	11		11	165.	
5	12		12	22580632.	
6	13		13	25205.3	
DRAG	14		14	.015	

If observations for a second satellite are to be input, Lines 1 through 14 are used for entry of epoch, initial conditions, and drag coefficient for Satellite 2. Lines 1 through 3 contain the year, month, and day, and Lines 4 through 6 contain the hour, minutes, and seconds, Greenwich time. Line 7 indicates the type of initial conditions that may be entered in Lines 8 through 13 (Type 1, 2, 3, 4, 8, or 9). Line 14 contains the drag coefficient (CDA/W). The input initial conditions

for IC Types 1, 2, and 3 is as shown in Section 3.3.2.

b. DPRAM (Differential Equation Parameters)
(Lines 16 through 20)

The ordering of DPRAM differential equation parameter entries is as shown in Section 3.3.2. However, in this application the T_1 and T_2 parameters are associated with Satellite 1 only.

c. PSAT2 through PSAT6 (Initial Condition and Drag Coefficient Parameters for Satellites 2-6)
(Lines 21 through 25)

The ordering of PSAT IC and drag parameter entries for Satellites 2 through 6 is shown below.

PSAT2	α_2	δ_2	β_2	A_2	r_2	v_2	t_{02}	DRAG ₂
PSAT3	α_3	δ_3	β_3	A_3	r_3	v_3	t_{03}	DRAG ₃
PSAT4	α_4	δ_4	β_4	A_4	r_4	v_4	t_{04}	DRAG ₄
PSAT5	α_5	δ_5	β_5	A_5	r_5	v_5	t_{05}	DRAG ₅
PSAT6	α_6	δ_6	β_6	A_6	r_6	v_6	t_{06}	DRAG ₆

It is important to note that only IC Type 2 may be specified for Satellites 2 through 6.

d. KPRAM (Orbit Parameters for Satellite 1)
(Lines 26 and 27)

Ordering of KPRAM orbit adjust parameters is as previously shown in Section 3.3.2. It should be noted that the orbit adjusts are for Satellite 1 only.

Sixty trajectory parameters is the maximum number which may be selected for simultaneous solution.

3.5.2.2 Radar Parameters

28	M	RAPAR	05, 99	
29	D	01, 01	B N L A T	
30		03, 01	.01	
31		04, 01		
32	D	01, 02	C K 2 4 R B I A S	
33		03, 02	500.	
34		04, 02	750.	
35	D	01, 03	H U T B I A S	
36		03, 03	.001	
37		04, 03	.0035	

Line 28 indicates that the data listed subsequent to RAPAR on the load sheet will be input into a 5×99 matrix array which has been preset to zero. The columns of this array correspond to parameters, and the rows correspond to parameter identification (Positions 1 and 2), bounds (Position 3), and bias estimates (Position 4) respectively. Row 5 is currently not used.

Lines 29 through 31 specify the first applicable radar parameter. Line 29 contains the station name (Positions 1 and 2), pass identification (Positions 3 and 4), and parameter name (Positions 5 through 10). Lines 30 and 31 contain the bound and initial value, respectively, in feet, degrees, and minutes except for \dot{R} , \dot{P} , and \dot{Q} , which are in feet per second. If the parameter is station latitude, longitude, or altitude, the initial value is taken from the station location card.

If the pass identification character position is left blank, all data with the indicated station name will be used to correct the parameter. If the pass identification is not omitted, only data that are identified by both the indicated station name and indicated pass identification will be used to correct the parameter. If the radar parameter specified is station latitude, longitude, or altitude, the pass identification is ignored and all data with the station name are used for the parameter correction.

Lines 32 through 34 and Lines 35 through 37 specify the second and third radar parameters respectively. Station names, pass identifications, parameter names, bounds, and initial values are treated in the same manner as the inputs in Lines 29 through 31 described above. Additional cards may be added in cases where more than three radar parameters are involved. Available radar parameters are listed in Table 9.

Note that the total number of parameters which may be selected for simultaneous solution must be less than one hundred.

Table 9.

PARAMETER	SYMBOL
Station latitude	LAT
Station longitude	LONG
Station altitude	ALT
Time bias	TBIAS
Range bias	RBIAS
Azimuth bias	ABIAS
Elevation bias	EBIAS
Topocentric right ascension bias	RTBIAS
Topocentric declination bias	DTBIAS
Topocentric hour angle bias	HABIAS
Geocentric right ascension bias	RGBIAS
Geocentric declination bias	DGBIAS
Argument of latitude (u) bias	UBIAS
Cross plane (v) bias	VBIAS
Height bias	HBIAS
\hat{x} bias	XBIAS
\hat{y} bias	YBIAS
\hat{z} bias	ZBIAS
P bias	PBIAS
Q bias	QBIAS
Range-rate bias	RDBIAS
\dot{P} bias	PDBIAS
\dot{Q} bias	QDBIAS
Range scale factor (K_R)	KR
Range-rate scale factor (K_D)	KD

3.5.3 Lines 38-50 Parameter Bounds

38		BNDS	.5	
39		2	.5	
40		3	.1	
41		4	.5	
42		5	1000.	
43		6	5	
44		7	.05	
45		8		
46		9		
47		10		
48		11		
49		12		
50		13		

A bound must be entered for each parameter selected. These bound entries must be in the same sequence as the parameters. For each iteration of the differential correction process, the change in each parameter is less in absolute value than the corresponding bound if that bound is positive, zero if the corresponding bound is zero, or unrestricted if the corresponding bound is negative.

3.5.4 Lines 51-62 Observation Sigmas

51		SIGMA	100.	
52		2	.5	
53		3	.5	
54		4	1000.	
55		5	200.	
56		6	300.	
57	I	ISIG	1	
58	I	2	2	
59	I	3	3	
60	I	4	113	
61	I	5	114	
62	I	6	115	

The observation sigmas for each observation type must be input in the same manner as was previously well described in Section 3.4.3.

3.5.5 Line 63 Maximum Iterations

63	I	MAXIT	4	
----	---	-------	---	--

The symbol MAXIT must be input with an integer value to specify a stopping point to the run. If the differential correction process has not converged at the end of MAXIT iterations, the process will be terminated.

3.5.6 Lines 64-66 Residual Editing

64		CEDIT	3	
65		2	.9	
66		3	1	

If CEDIT is zero, no editing is done. If CEDIT is non-zero, residuals will be edited in accordance with the following:

- a. CEDIT < 0 Residuals greater than (input $\sigma \times |CEDIT|$) will be discarded.
- b. CEDIT > 0 Residuals greater than (statistical σ from the previous iteration $\times CEDIT$) will be discarded. No editing is done on Iteration 1. Sigmas are computed for the first five data types encountered for each station.

Line 65 represents a scale factor such that if CEDIT(2) is non-zero, CEDIT is replaced by (CEDIT \times CEDIT(2)) at the end of each iteration. If CEDIT(2) is zero, CEDIT is not modified.

Line 66 is a special option wherein if CEDIT(3) is non-zero, Iteration 1 will be repeated with editing performed with the sigmas computed during the first pass through Iteration 1. This will allow editing to be done on all iterations with computed sigmas.

Sigmas (rms) for the first five data types for each station are computed and printed at the end of each iteration regardless of the residual-editing option selected.

3.5.7 Data Correction Factors

3.5.7.1 Lines 67 and 68 Elevation Angle Refraction

67		REFR		
68		2	4.0	-6

A table of refraction indices n_i , which may contain up to ten values, may be input starting at REFR. The entry used to compute refraction corrections for radar elevation observations is determined by the type number contained in Column 6 of the corresponding station location card. A zero in Column 6 causes the entry at REFR to be used, a 1 in Column 6 causes the entry at REFR + 1 to be used, etc.

If the table contains no entries, the value 312.0×10^{-6} , which is built in at location REFR, will be used to

compute refraction corrections for all data whose station location cards contain zero in Column 6. All other positions of the table are assembled as zeros.

3.5.7.2 Range Refraction Correction

69		RREFC	1	
----	--	-------	---	--

Refraction corrections to all range observations will be computed and applied if RREFC is non-zero.

3.5.7.3 Line 70 Propagation Time Correction

70		SLT	-2820.1763	
----	--	-----	------------	--

The velocity to be used in calculating the observation time correction due to propagation time is entered at SLT in units of earth radii per minute. In the absence of an entry, no correction will be applied. If an entry is present the correction will be applied to times associated with R, A, E, \dot{R} , h, P, Q, \dot{P} and Q data only.

3.5.8 Lines 71, 72 Data Tape Options

71	I	IBCDI	6	
72	I	IBINI	1	

If the radar observation and station location information is to be input via a BCD tape other than the normal FORTRAN system input tape, the tape number must be specified at IBCDI as 11. If a binary tape containing compacted radar data produced by a previous run is to be input, IBINI must be specified.

3.5.9 Lines 73, 74 True Equinox Correction

73		DALFG	-.004	
74		2		

An additive factor may be applied to the computed right ascension of Greenwich at midnight of epoch day by entering the appropriate value in units of degrees at DALFG for Vehicle 1, at DAFLG(2) for Vehicle 2, etc. This entry usually is used to correct from mean to true equinox reference coordinates.

3.5.10 Lines 75-78 Proximity Indicator

ϕ^*	75		ANØM1	
λ	76		2	
h	77		3	
R_0	78		4	

During an orbit determination run, an indicator may be obtained whenever the trajectory passes within a given distance (range) of a point on the surface of the earth by input of geodetic latitude (deg), east longitude (deg), and altitude (n mi) of the point at ANØM1 and the succeeding two positions and of the testing distance (the range from the point to the vehicle) at AMON1(4). Testing and printing is done for up to three such sets of input at AMON1, ANOM2, and ANOM3.

3.5.11 Lines 79 on Parameter Constraint Options

There are two different parameter constraint options available in TRACE-D. Both are described below in detail.

3.5.11.1 General Constraint Matrix

Option 1 allows the user to apply linear constraints to any of the variables in the parameter set, and to specify these constraints by means of an input matrix set up as shown below.

	79	I	KNST	4	
	80	I	BLIST	1	
	81			1	
b ₁₁	82			1	
	83	I		2	
	84	I		2	
b ₂₂	85			1	
	86	I		3	
	87	I		3	
b ₃₃	88			1	
	89	I		4	
	90	I		4	
b ₄₄	91			1	
	92	I		5	
	93	I		1	
b ₅₁	94			-1	
	95	I		6	
	96	I		2	
b ₆₂	97			.5	
	98			5	
	99	I		5	
c ₅₁	100			6	
	101	I		7	
	102	I		5	
	103			1	

The clearest explanation of how this constraint matrix works is an example. Therefore, in the case shown above it is assumed that n parameters are to be solved for where $(p_1, p_2, \dots, p^n) = P$. The ordering of the P_i corresponds to the

order of the X 's for the CPRAM, DPRAM, and KPRAM and the RAPAR arrays, respectively. Further assuming that these parameters are to be subjected to m linear constraints, which, for example for $n = 6$ and $m = 2$ might be $p_1 + p_5 = 6$, $p_2 - 2p_6 = 0$, KNST above would be equal to $(n - m) = 4$, or the number of effective (unconstrained) parameters.

The BLIST constraint matrix is represented by the factor B in the expression $p = B\bar{p} + c$, where the \bar{p} are the effective parameters. In connection with the foregoing example, this expression would assume the form

$$\underbrace{\begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \\ p_5 \\ p_6 \end{bmatrix}}_p = \underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -1 & 0 & 0 & 0 \\ 0 & .5 & 0 & 0 \end{bmatrix}}_B \times \underbrace{\begin{bmatrix} \bar{p}_1 \\ \bar{p}_2 \\ \bar{p}_3 \\ \bar{p}_4 \end{bmatrix}}_{\bar{p}} + \underbrace{\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 6 \\ 0 \end{bmatrix}}_c$$

Pertinent constraints are applied by input of the augmented $(n + 1)$ by $(n - m + 1)$ matrix

$$\begin{bmatrix} B & c \\ 0 & 1 \end{bmatrix}$$

in the BLIST array. If a_{ij} is an element of this augmented matrix, then i , j , and a_{ij} would be input. The inputs for the example given above would be as indicated in Lines 79-103. KNST (line 70) is input as 4 and then the BLIST matrix follows. Lines 80, 81, and 82 specify that BLIST (1, 1) is a 1 and lines 83, 84, and 85 that BLIST (2, 2) is a 1, etc. Elements of the matrix not input are assumed to be zero. In this way any subset of the set of parameters may be linearly constrained and the constraint matrix may be input to the program in the exact same manner.

3.5.11.2 Special Application to Station Location

The other option available is a specific case of the general constraint matrix which is applicable in the following type of problem. Consider a differential correction run with data from a tri-static system and a set of parameters including the latitudes, longitudes and altitudes of the three stations. In such a case, by choosing this constraint option, the correction of the station coordinates can be performed such that the baseline distances are held constant.

Mathematically, this implies that three constraining equations¹ are applied to the nine station locations; more specifically they are of the following form.

$$\Delta\phi_1 = a_1 \Delta\theta_1 + a_2 \Delta H_1 + a_3 \Delta\theta_2 + a_4 \Delta H_2 + a_5 \Delta\phi_3 + a_6 \Delta H_3$$

$$\Delta\phi_2 = b_1 \Delta\theta_1 + b_2 \Delta H_1 + b_3 \Delta\theta_2 + b_4 \Delta H_2 + b_5 \Delta\phi_3 + b_6 \Delta H_3$$

$$\Delta\theta_3 = c_1 \Delta\theta_1 + c_2 \Delta H_1 + c_3 \Delta\theta_2 + c_4 \Delta H_2 + c_5 \Delta\phi_3 + c_6 \Delta H_3$$

where

(θ_1, ϕ_1, H_1)	are the three sets of latitude,
(θ_2, ϕ_2, H_2)	Longitude, and altitude for
	Stations 1, 2, and 3.
(θ_3, ϕ_3, H_3)	

and a_i, b_i, c_i $i = 1, \dots, 6$ are the 18 coefficients of the three equations.

With the equations in this particular form, it seems that the general constraint option could be applied easily. However, there are two reasons for the separate treatment of this application that are not immediately apparent. First, the constants a_i, b_i, c_i $i = 1, \dots, 6$ are functions of the current station location² and are not easily and accurately calculable by the user. Second, since

¹ The detailed derivation of this particular form of the constraining equations is not given here but may be found in Reference 3.

² The exact expressions for the coefficients can be found in Reference 3.

the constants are functions of the current station locations, they must be reevaluated every time the station locations change (i.e., after every iteration of the correction process the constants must be reset since the station locations have been adjusted). In other words, the type of constraint matrix needed here is a dynamic one that is adaptable to change throughout the estimation procedure. It is now obvious that the general constraint matrix of Section 3.5.11.1 is too rigid for this purpose.

Thus, added to the TRACE-D program is the capability to compute these necessary constants from input information, insert them into the appropriate location of the constraint matrix, recompute the constants as a function of the new station locations after each iteration and adjust the constraint matrix accordingly. Once the user has set up the appropriate input the rest is performed by the program.

The input necessary is best described with an example. Consider a differential correction run with data from three stations and a parameter set consisting of the ADBARV elements, drag, and station locations. To employ the fixed baseline distance constraints on the station locations consider B in the following expression.

$$\Delta \rho' = B \Delta P + c$$

There are 16 parameters to be estimated but there are 3 constraint equations, therefore there are 13 effective or unconstrained parameters. B is then of dimension 16×13 and looks like this:

$$\begin{array}{c}
 [\Delta \rho'] = [B] \\
 \begin{array}{c}
 \Delta \alpha \\
 \Delta \delta \\
 \Delta B \\
 \Delta A \\
 \Delta R \\
 \Delta V \\
 \Delta \text{ drag} \\
 \Delta \text{ lat}_1 \\
 \Delta \text{ long}_1 \\
 \Delta \text{ alt}_1 \\
 \Delta \text{ lat}_2 \\
 \Delta \text{ long}_2 \\
 \Delta \text{ alt}_2 \\
 \Delta \text{ lat}_3 \\
 \Delta \text{ long}_3 \\
 \Delta \text{ alt}_3
 \end{array}
 =
 \begin{array}{c}
 \begin{array}{cccccccccccc}
 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_1 & a_2 & a_3 & a_4 & a_5 & a_6 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
 \end{array} \\
 \end{array}
 \begin{array}{c}
 \begin{array}{c}
 \Delta \alpha \\
 \Delta \delta \\
 \Delta B \\
 \Delta A \\
 \Delta R \\
 \Delta V \\
 \Delta \text{ drag} \\
 \Delta \text{ long}_1 \\
 \Delta \text{ alt}_1 \\
 \Delta \text{ long}_2 \\
 \Delta \text{ alt}_2 \\
 \Delta \text{ lat}_3 \\
 \Delta \text{ alt}_3
 \end{array}
 +
 \begin{array}{c}
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0 \\
 0
 \end{array}
 \end{array}
 \end{array}$$

The quantities $a_i, b_i, c_i, i = 1, \dots, 6$ are, of course, the coefficients in the constraint equations which are unknown to the user.

This B matrix is input in exactly the same manner as the general constraint matrix except that each element that is a coefficient (either a_i, b_i, c_i) must be input with a value of - 10,000. This is merely to indicate to the program the position in the matrix of these terms.

Lines 104 on show the appropriate format for the necessary input of this case.

104		NUMB		116	I	8	
105	I	44	-1	117	I	8	
106	I	KNST	13	118	I	-10,000.	
107	I	BLIST	1	119	I	8	
108	I		1	120	I	9	
109			1	121		-10,000.	
110	I		2				
111	I		2		etc.		
112	:		1				
113	:						
114	etc.						
115							

Lines 104 and 105 specify the quantity NUMB(44) which must be input as a - 1 to choose this constraint option. Line 106 is the number of unconstrained parameters in the parameter set. Lines 107 on are the non-zero elements of the B matrix entered in order.

3.5.12 Station Identification Cards

The locations of tracking stations or of points on the surface of the earth which are associated with observations must be input by means of station cards carrying appropriate information indicating the manner in which the corresponding observations are to be processed. These cards were previously discussed in Section 3.4.5 and shown in Figure 1, but the format is included again here for completeness.

- a. Columns 1 and 2 (ST): Station identification symbol. No two stations may be identified by the same symbol or any one station by the symbol TS.
- b. Column 5: Sigma index identifying observation-sigma set to be applied to data from corresponding station. The sets of sigmas are input with the base data.
- c. Column 6: Type of refractivity correction to be used for elevation readings from this station. Refractivities are numbered in their input order within the base data (see Line 67, REFR).

- d. Columns 9 through 17: North latitude of station in degrees.
- e. Columns 19 through 27: East longitude of station in degrees.
- f. Columns 29 through 36: Altitude of station in feet.
- g. Columns 38/39 and 41/42: If a station reports P, Q, or P, Q data, Columns 38/39 and 41/42 contain the two letter symbols for the associated station(s) of the tracking configuration. Each such associated station must be represented by a separate station card, but it is not necessary for Columns 38/39 and 41/42 to be filled out on the latter.

These cards must be preceded by a card with END in Columns 1-3 and followed by a card with TS in Columns 1 and 2.

3.5.13 Observation Data Cards

The observations to be processed must be the last set of cards in the deck and must follow the station location cards.

Since the number of observations that may be input to TRACE-D is unlimited, there is a flocking procedure that must be followed. A flock of data consists of 200 or less observation cards for a single satellite. There is no limit to the number of flocks that can be stacked; however, each flock must be followed by a card with TF in Columns 1 and 2 and the times associated with the observations of a flock can never be earlier than the latest time of the previous flock. This means that the data is not time sorted within a flock but the flocks are sorted according to earliest and latest times therein contained.

The contents of an observation card is formatted in the following way, as shown in Figure 4.

- a. Columns 1 and 2 (ST): Station Identification, symbol which must correspond to a station location card.
- b. Columns 3 and 4: Pass identification (optional).
- c. Columns 5 through 21: month (columns 5 and 6), day (columns 7 and 8), hours (columns 9 and 10)

minutes (columns 11 and 12), and seconds (columns 13-21), of the corresponding observations relative to Greenwich Mean Time.

- d. Column 22: Observation set number.
- e. Columns 23-76: Observation 1 (columns 23-40), Observation 2 (columns 41-58), Observation 3 (columns 59-76).
- f. Column 77: Card number indicating observations, variances, or covariances.

The observation set (d) number and the card number (f) are the two indicators that define exactly what type of observations are contained on each card. Table 10 gives a complete listing of all types according to observation set number and card number.

After the last observation card in the deck, a TF card is not necessary, however a card with TR in Columns 1 and 2 plus an END card must be attached as the last two cards of the deck. If data from more than one satellite are to be used, the Satellite 1 data are set up in the same manner except that the TR card must be replaced by a TT card. The data for Satellite 2 are then similarly arranged. If Satellite 2 is the last vehicle, corresponding data are followed by a TR card and an END card: if it is not the last satellite, data are followed by a TT card. Data for Satellites 3 through 6, as applicable, are added in the same manner. A TR card rather than a TT card must follow the data corresponding to the last satellite, and an END card must follow the TR card. See Section 3.6 for a picture of the correct setup.

3.6 Input Deck Arrangements

Since the basic running deck to be used for each function to be performed can be obtained, the user need not concern himself with its contents. Therefore in each of the Figures the separate parts of this deck are ignored and it is labeled totally as the basic running deck. The categories of data used are described in detail in previous sections (for instance, Basic Data is explained in Section 3.2, etc.).

Observation Set Number (Column 22)		Observation Card Type (Column 77)	Field 1		Field 2		Field 3	
1	1	0	Slant range(R)	Azimuth (A)	Elevation(E)			
1	1	1	Variance(R)	Variance(A)	Variance(E)			
1	1	2	Covariance(R,A)	Covariance(R,E)	Covariance(A,E)			
2	2	0	Topocentric right ascension(α_T)	Topocentric declination(δ_T)	Topocentric hour angle (HA)			
2	2	1	Variance(α_T)	Variance(δ_T)	Variance(HA)			
2	2	2	Covariance(α_T, δ_T)		Covariance(δ_T, HA)			
3	3	0	Geocentric right ascension(α_g)	Geocentric declination(δ_g)				
3	3	1	Variance(α_g)	Variance(δ_g)				
3	3	2	Covariance(α_g, δ_g)					
4	4	0	Argument of latitude(u)	Cross plane(v)	Altitude(h)			
4	4	1	Variance(u)	Variance(v)	Variance(h)			
4	4	2	Covariance(u,v)	Covariance(u,r)	Covariance(v,h)			
5	5	0	\hat{x}	\hat{y}	\hat{z}			
5	5	1	Variance(\hat{x})	Variance(\hat{y})	Variance(\hat{z})			
5	5	2	Covariance(\hat{x}, \hat{y})	Covariance(\hat{x}, \hat{z})	Covariance(\hat{y}, \hat{z})			
6	6	0	Slant range(R)	Range difference(P)	Range difference(Q)			
6	6	1	Variance(R)	Variance(P)	Variance(Q)			
6	6	2	Covariance(R,P)	Covariance(R,Q)	Covariance(P,Q)			
7	7	0	Range rate(\dot{R})	Range rate difference(\dot{P})	Range rate differences(\dot{Q})			
7	7	1	Variance(\dot{R})	Variance(\dot{P})	Variance(\dot{Q})			
7	7	2	Covariance(\dot{R}, \dot{P})	Covariance(\dot{R}, \dot{Q})	Covariance(\dot{P}, \dot{Q})			

Table 10. Observation Types and Indicators

3.6.1 Trajectory Prediction Deck Arrangement

When the function to be performed is a single trajectory prediction (function code ITIN = 3), the arrangement is as in Figure 5.

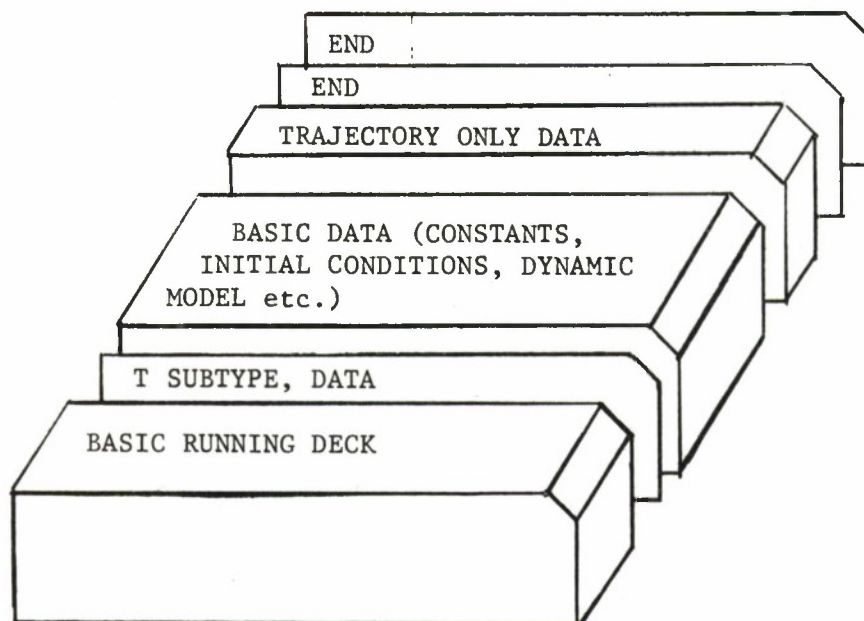


Figure 5.

TRAJECTORY PREDICTION DECK ARRANGEMENT

When several trajectory predictions are to be done in one run (function code ITIN = 333, etc.) then the deck arrangement is merely an extension of that for the single case (Figure 6).

3.6.2 Observation Generation Deck Arrangement

Figure 7 and Figure 8 show the correct data setup for a single data generation run (function code ITIN = 4) and several cases (function code ITIN = 4.4, etc.) respectively.

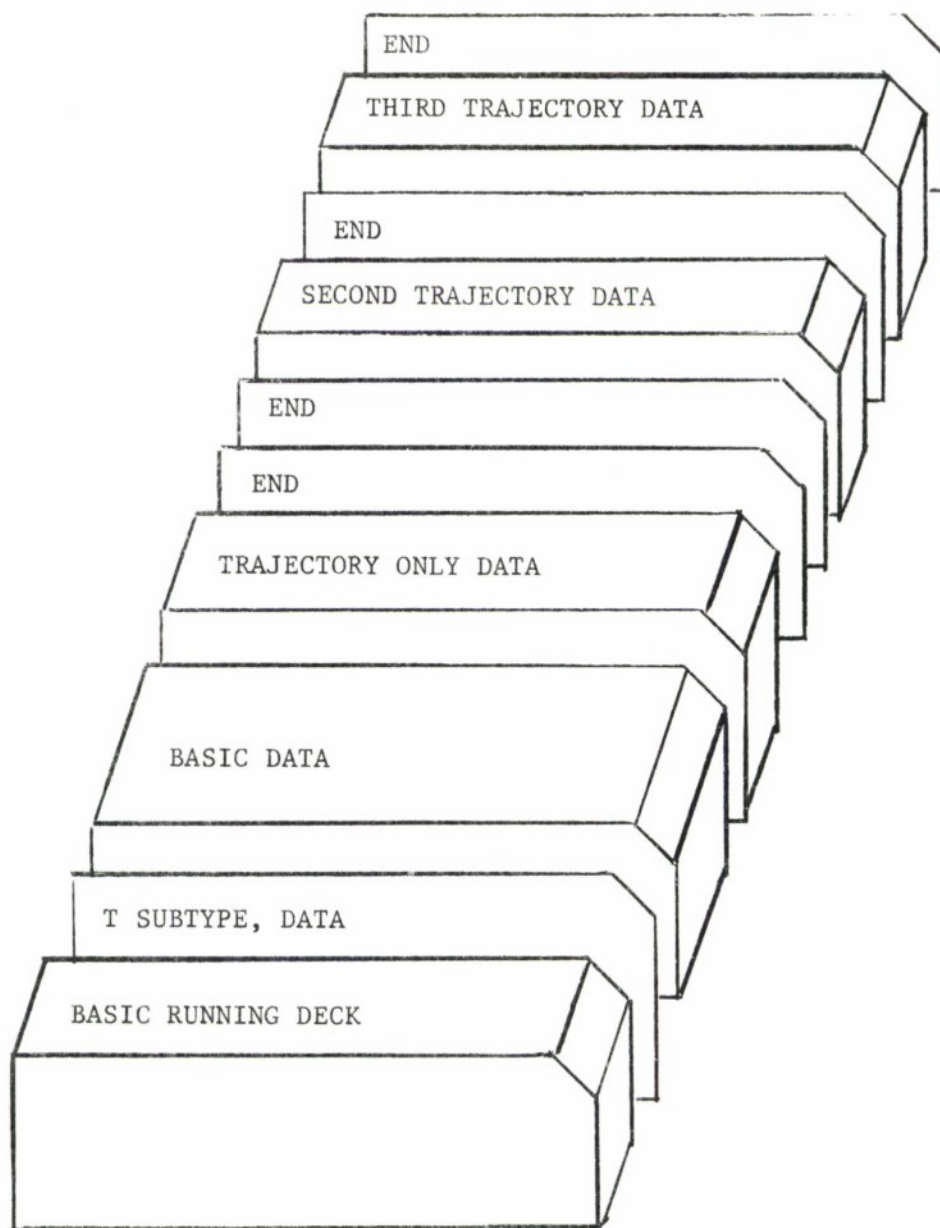


Figure 6.

MULTIPLE TRAJECTORY PREDICTIONS DECK ARRANGEMENT

Figure 7.

DECK ARRANGEMENT FOR
OBSERVATION GENERATION
SINGLE CASE.

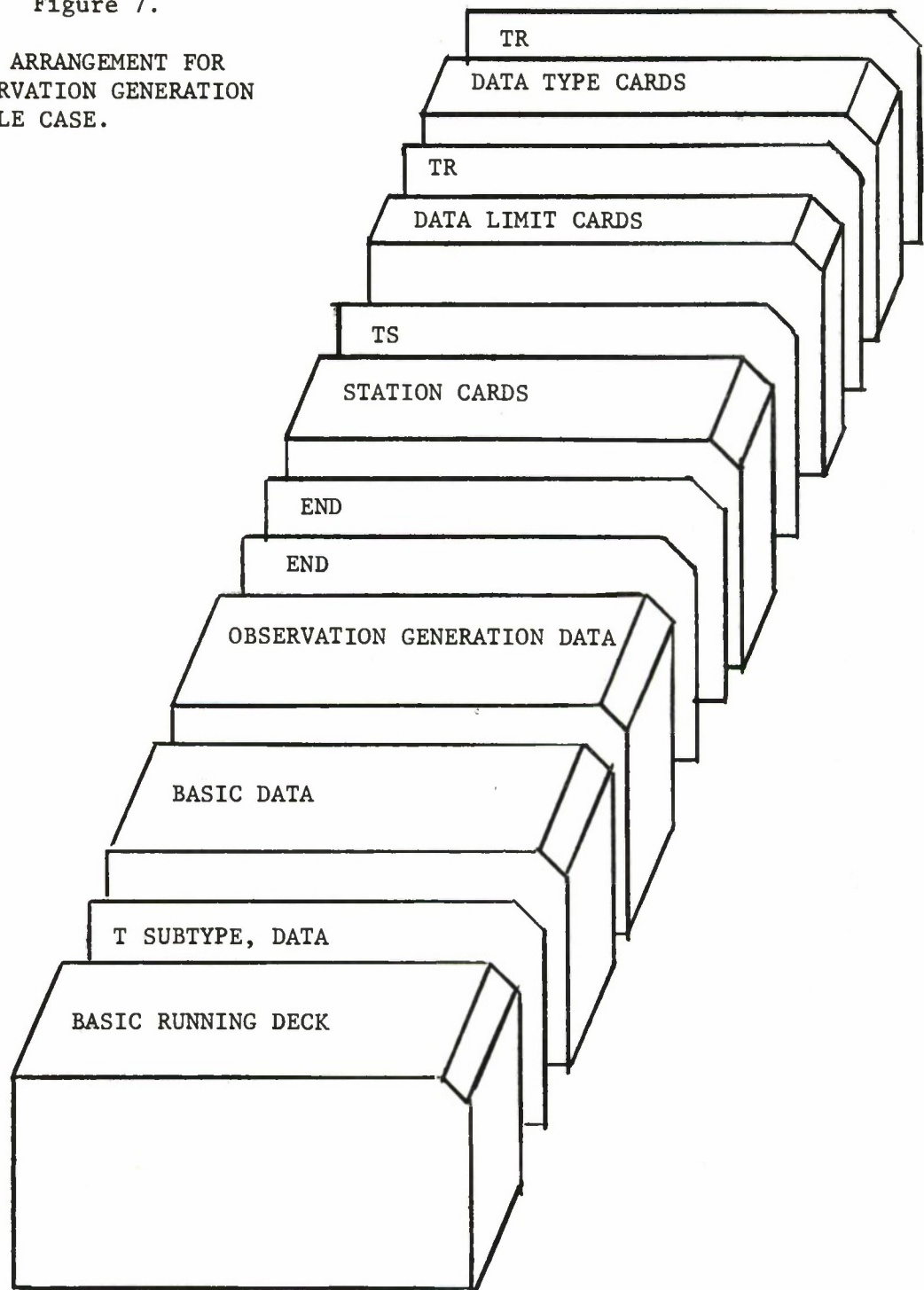
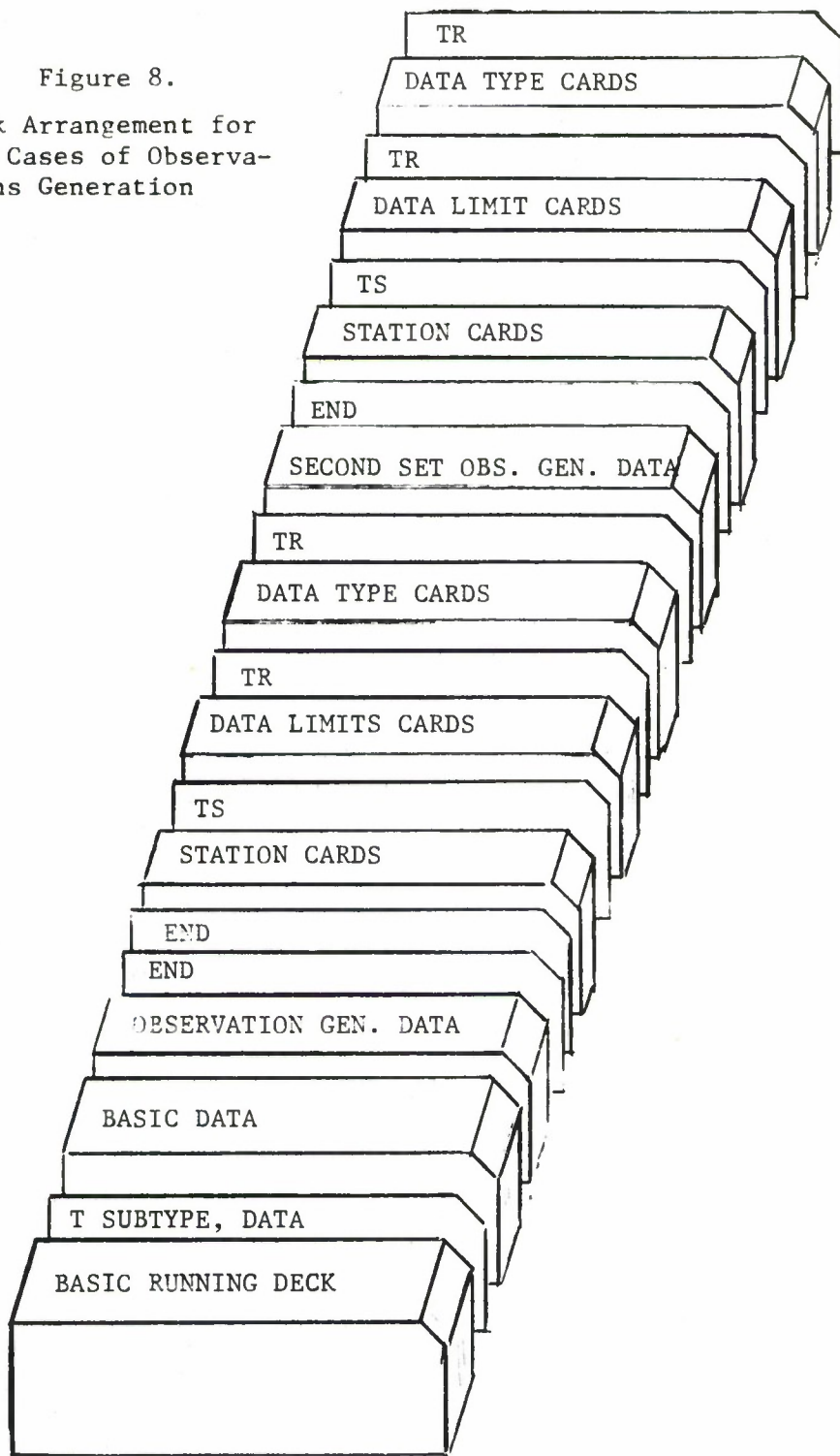


Figure 8.
Deck Arrangement for
Two Cases of Observa-
tions Generation



3.6.3 Orbit Determination Deck Arrangement

There are several different deck setups that are permissible for an orbit determination run (function code ITIN = 12) according to the choice of several suboptions.

Figure 9 is the simplest deck setup and applies when the observation data is being input on tape (i.e., IBCDI input variable is used).

Figure 10 is the ordinary deck setup for a single case when the observation data is attached to the deck. Figure 11 is the deck setup for two such stacked cases.

Figure 12 is the appropriate data arrangement for the situation of multiple satellites (in this case three satellites).

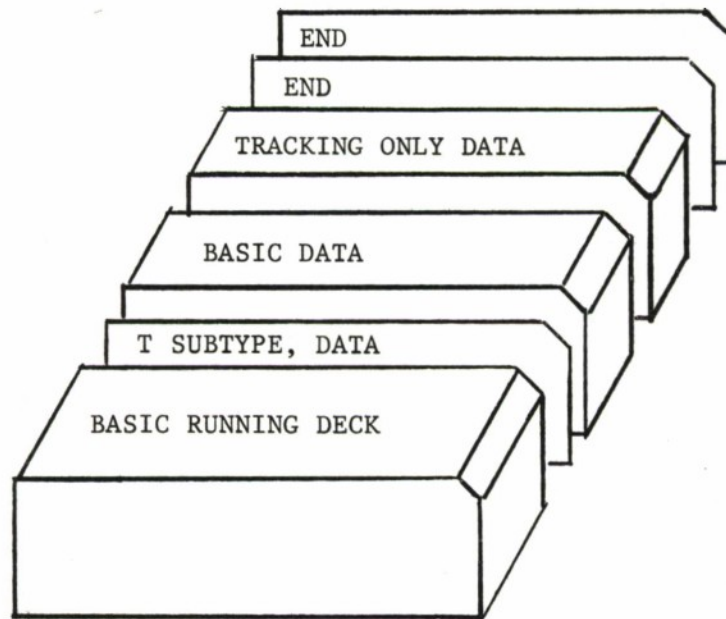


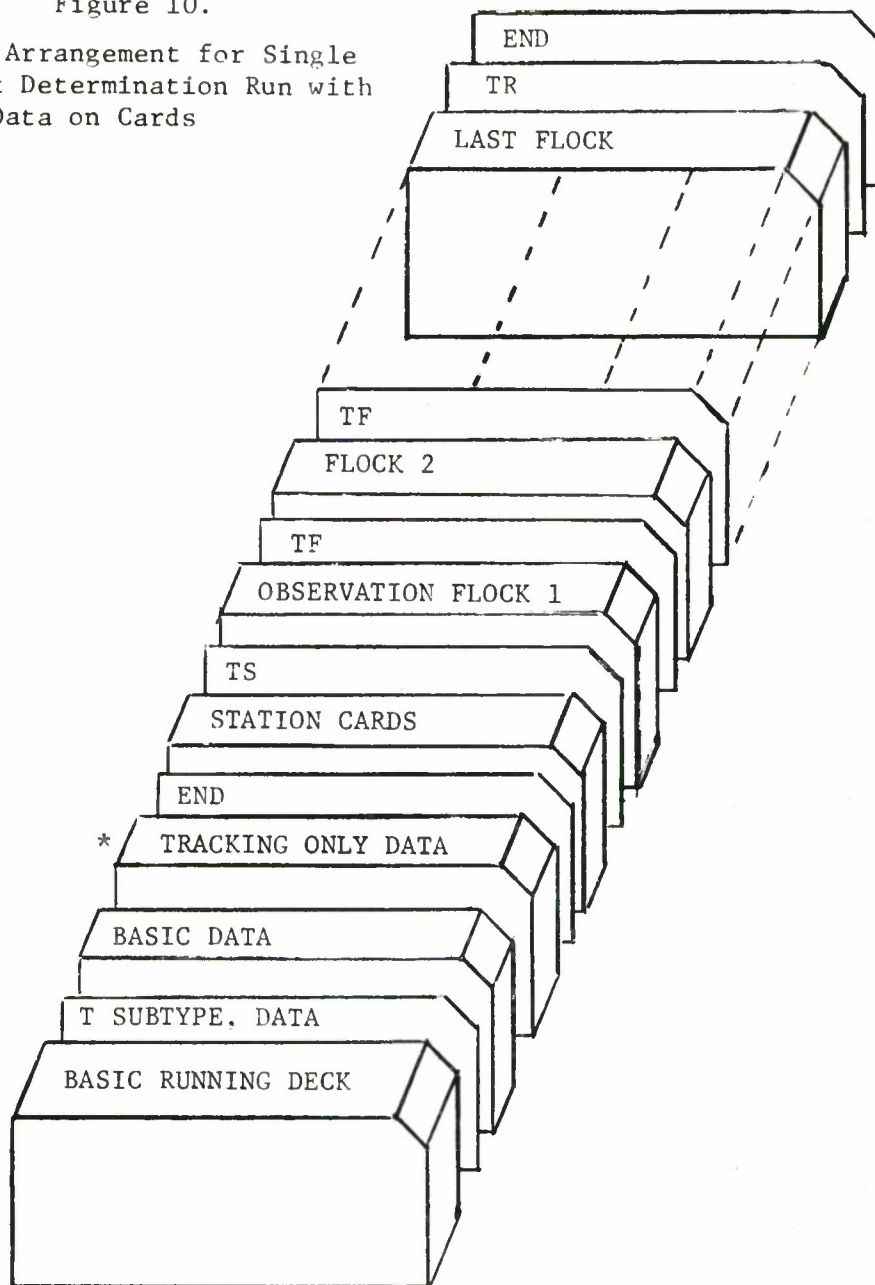
Figure 9.

Deck Arrangement for Orbit Determination with Input Tape*

- * Note that the BCD tape of observations must contain as its first set of cards the station cards followed by a TS card and then the observations in proper flocks followed by TF cards with a TR card replacing the TF card of the last flock.

Figure 10.

Deck Arrangement for Single
Orbit Determination Run with
All Data on Cards



* Note that the word "tracking" is used interchangeably with the words "Orbit Determination".

Figure 11.
Deck Arrangement for
Two Orbit Determination
Cases All Data on
Cards

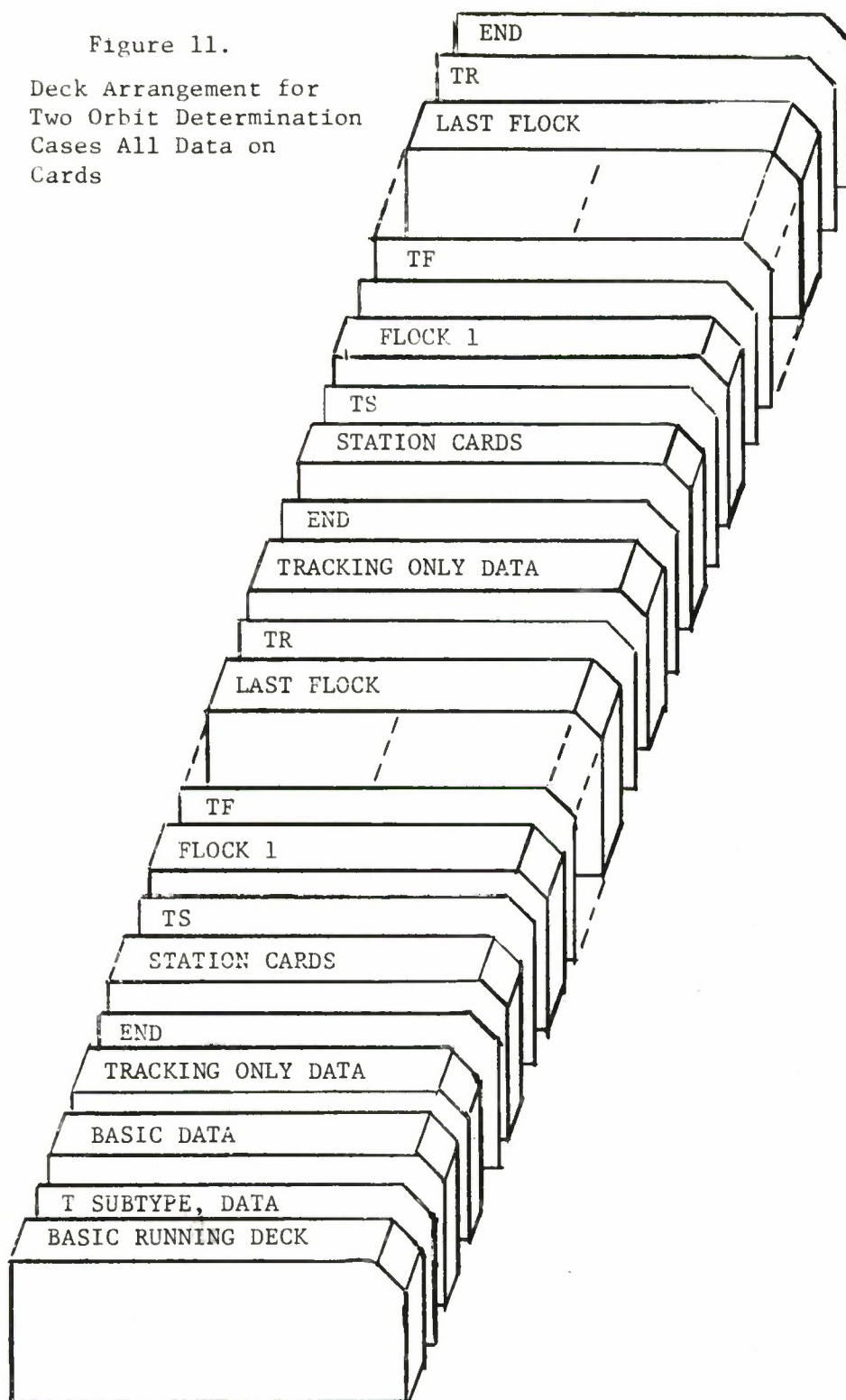
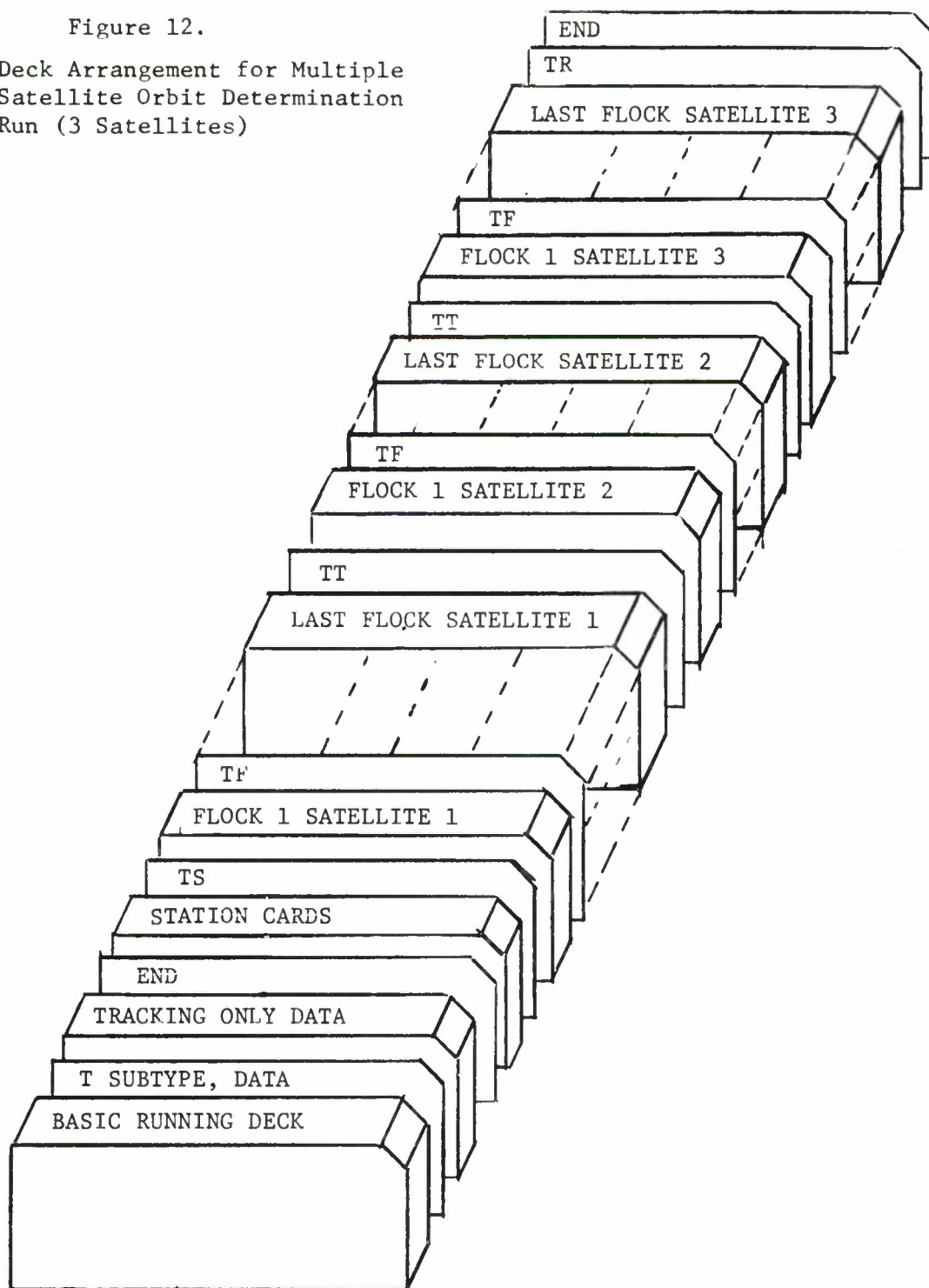


Figure 12.
Deck Arrangement for Multiple
Satellite Orbit Determination
Run (3 Satellites)



3.6.4 Sample Input Decks

Figures 13, 14, and 15 are listings of sample data decks for trajectory prediction, observation generation, and orbit determination. Besides giving the user an idea of what a typical deck looks like, they may also be used to familiarize the user with the operation of TRACE-D before he creates his own input. Another reason for running a test case of this sort is to determine the status of the program tape, for it is possible for the contents of a tape to deteriorate and no longer be useful¹.

It is not to be assumed that these sample cases exercise all the possible options of TRACE-D, but rather that they exhibit typical input and output. A complete description of the output obtained from these runs is included in Section 4.

¹ In this instance, there is no cause for alarm. MITRE has the capability to create a new and correct program tape in 24 hours.

Figure 13.

T	SUBTYPE	DATA	GINTEG	TRACE-D	STANDARD	INTEGRATION	CONSTANTS
11	1	12	2	13	0		
4	1	5	1	11	1.00002516		
23	1	-9					
26	1						
30	1	31	0.015625	32	64	33	1
134	4	135	1	37	0.0001	38	0.
40	2820.18012	141	1				
GC	TRACE-D	STANDARD	PHYSICAL	CONSTANTS	10/	1/65	
1	437526904	-2	2	5530370	-2	6	5
8	437526904	-2	9	1.	10	10	
13	3280.8399	14	57.2957795	15	20925738		
16	332951.3	17	0.01229853	18	814979		
19	107821	20	317.387	21	95.129		
22	23454.865	23	3443.93355	24	20925738		
25	348762.3	26	32.174	30	348762.3		
31	1.5	32	1.0471976	33	5.14159265		
34	298.3	35	300000.	36	82505.922		
NUMB	42	3443.9336					
11FLAG	128	0					
110B	14	15		13	14	14	15
OBJZ	2	1082.645	-6	3	-2.546	-6	4
5	-210	-6					
6	646	-6					
7	-333	-6	8	-270	-6		
9	-053	-6					
10	-054	-6	11	302	-6	12	-357
14	179	-6					
OBJT	2	1765980	-5	3	2110765	-5	4
6	7017339	-6	7	1652	-6	8	9
10	1111635	-6	11	1083012	-6	12	1717943
14	1507404	-8	15	4264694	-7	16	4633369
18	1967936	-8	19	4477079	-9	20	3729502
22	3972437	-7	23	35430592	-8	24	3897152
26	1515140	0	27	2052417	0	28	6820109
30	3762496	-9	31	2771455	-9	32	2341330
34	1641761	0	35	3418347	0	36	7643382
44	8609215	0	45	1013471	-8	46	6724120
48	7857074	0	55	3251625	-7	56	1006553
77	2783799	0					
89	1717906	0	90	3549629	0	91	8360489

Figure 13 (cont.)

101	.1059143	KC
102	.1326684	J9 104 .1974783 K1
113	.5398041	J8 116 .1393759 J9 117 .1492896 K0 118 .5702221 K2
OBLT		
2	165.2042	3 7.823267 4 161.8799 5 23.63307
6	219.3494	7 31.73482 8 115.8047 9 25.74411
10	232.5121	11 169.9065 12 59.74292 13 41.60563
14	56.95252	15 209.876 16 140.3382 17 50.04699
18	66.28621	19 47.13021 20 42.58828 21 38.37493
22	12.06147	23 1.37273 24 53.46592 25 7.078959
26	27.20422	27 8.598698 28 139.0856 29 28.15497
30	57.94327	31 45.80993 32 22.83747 33 15.51001
34	15.09665	35 19.70539 36 5.856014 37 48.25990
44	13.95194	45 309.8056 46 100.9007 47 68.25838
48	59.07748	55 164.1975 66 203.5371 67 91.41733
77	14.87681	
89	11.44440	90 9.804658 91 160.5400
101	30.31227	102 23.00277 104 13.72105
116	15.65423	
117	16.80139	118 20.10848
DITIN 3		
IICTYP2		
IC	358.2	
2	-25.5	
3	90.35	
4	47.18	
5	22999226.	
6	24797.530	
IPRTMO		
12	1	3 0. 4 5.
5	60.	
6	30.	7 00.
DRAG .00B		
12	1	
3	6.83	4 -15.684
IYEAR	1967	IMNTH 7
IDAY	8	TZNE 0.
HR	15.	MIN 0.
DPRDEX	X	SEC 0.
PTAPE	4	
END		
END		

SUBTYPE.DAT

85	4	-15.684
----	---	---------

1

GC	STANDARD DECK FOR GUIERS 6. TH ORDER EARTH MODEL	10/15/65
1	.043752695-1 2 .55304505 -2 15 20925741.	
24	20925741. OBJT	
3	1.856 -6 4 .4482	-6
6	.7278 -6 7 .1536	-6
9	.004781 -6 10 .1509	-6
12	.005842 -6 13 .004093	-6
15	.06611 -6 16 .03746	-6
18	.002256 -6 19 .0003328	-6
OBLT	2 -13.18 3 5.31	
4	-13.33 5 16.00 6 -136.68	
7	27.47 8 -1.10 9 36.01	
10	-81.86 11 -2.60 12 -3.45	
13	58.25 14 -15.32 15 157.21	
16	113.15 17 -1.75 18 60.74	
19	-17.75 20 -14.34 05JZ	
2	1082.76 -6 3 -2.693 -6 4 -1.56 -6	
5	-.006 -6 6 .39 -6 7 -.633 -6	
8	0. 9 .210 -6 10 9	
12	6 13 9 14 6	
DATE	1 YEAR 1965 1 MONTH 2	

Figure 14 (cont.)

IDAY	23
IICIVP4	
IC	-60.
2	0.
4	25.
5	-607612.
6	-1.
IPTAPE4	
BNOISE1	
13	3
16	6
19	13
112	19
3	.1
7	.05
10	1000.
END	
MRAPAR05.99	
DQ1.01BB	RBIAS
03.01	1000.
END	
AA	75.0
BB	45.0
CC	0.
DD	0.
EE	-15.0
FF	-65.0
TS	
AA	15.
BB	15.
CC	15.
DD	15.
EE	15.
FF	15.
TR	
AA	XXXX
BB	XXXX
CC	XXXX
DD	XXXX
EE	XXXX
FF	XXXX
TP	

Figure 15

SUBTYPE DATA		TRACE-D STANDARD INTEGRATION CONSTANTS									
GINTEG	TRACE-D	STANDARD	INTEGRATION	CONSTANTS							
11	1	12	2	13	0						
4	1	5	1	11	1.00002516						
23	.1	-9									
26	1										
30	1	31	.015625	32	64	33	1	-7			
134	4	135	1	37	.0001	38	0.				
40	2820.16012	141	1								
GC	TRACE-D STANDARD PHYSICAL CONSTANTS 10/ 1/65										
1	.437526904-2	2	.55304203	-2	6	.5					
8	.437526904-2	9	1.	10	10						
13	3280.8399	14	57.2957795	15	20925738						
16	332951.3	17	.01229853	18	.814979						
19	.107621	20	317.687	21	95.129						
22	23454.865	23	3443.93355	24	20925738						
25	348762.3	26	32.174	30	348762.3						
31	1.5	32	1.0471976	33	3.14159265						
34	298.3	35	300000.	35	82505.922						
NUMB	42 3443.9336										
DITIN 12											
DPRCDE X X											
11CTYP2											
IC	23.11454										
2	26.51516										
3	89.88977										
4	45.73312										
5	24780836.7										
6	23765.259										
IMAXIT1											
1YEAR 1967											
1MNTH 7											
1DAY 8											
TZNE 0											
HR	14.										
MIN	45.										
DRAG	.2849										
3	6.83										
110B	10										
14	6										
OBJZ											
2	.1082645										
3	-.2546000										
4	-1.649										

Figure 15 (cont.)

5	-.210	-6 6	.646	-6 7	-.333	-6
8	-.270	-6 9	-.053	-6 10	-.054	-6
OBJT		2	1.5664	-6 3	1.7287	-6
4	.3025	-6 5	.1966	-6 6	.5234	-6
7	.1372	-6 8	.04166	-6 9	.009376	-6
10	.1247	-6 11	.05846	-6 12	.02219	-6
13	.001605	-6 14	.001029	-6 15	.09572	-6
16	.02928	-6 17	.001037	-6 18	.001500	-6
19	.000381	-6 20	.000140	-6		
OBLT		2	-15.50	3	-1.43	
4	-32.30	5	32.31	6	-133.53	
7	35.75	8	-2.75	9	26.09	
10	-164.13	11	-24.19	12	58.58	
13	32.27	14	-15.79	15	99.46	
16	-38.87	17	0.0	18	-19.96	
19	-25.28	20	-16.92			
SIGMA	22.96					
2	.06056					
3	22.96					
4	.06056					
5	22.96					
6	.06056					
IPTAPE	4					
IISIG	101					
12	119					
13	201					
14	219					
15	301					
16	319					
DCPRAM	2XXXXXX					
DDPRAM	XXXXX					
BND	1.5					
2	1.5					
3	.3					
4	.75					
5	4920.					
6	492.					
7	.15					
8	.1	-7				
9	.1	-7				
10	.1	-7				

END
 MH 1 42.617373 289.50953 223.0970
 BD 2 42.505961 285.76481 -91.8640

Figure 15 (cont.)

BH	3	42.645973	285.90644	+154.199
TS				
MH	7	8145316.7706017	-17007.799540638	
MH	7	8145321.2185237	-16953.515419959	
MH	7	8145325.5664477	-16893.817585227	
MH	7	8145329.9603707	-16841.864501236	
MH	7	8145334.4422917	-16781.986876605	
MH	7	8145338.7262187	-16723.026246665	
MH	7	8145342.5561527	-16668.616601036	
MH	7	8145343.5394681	8494671.751891473	
MH	7	8145346.4340867	-16612.446522233	
MH	7	8145350.2880207	-16554.962598321	
MH	7	8145354.0479567	-16497.401902913	
MH	7	8145357.9418897	-16436.200131176	
MH	7	8145358.5792151	8245884.580015854	
MH	7	81454 1.7558247	-16374.666010437	
MH	7	81454 5.5157637	-16312.415026127	
MH	7	81454 9.2756987	-16248.541010438	
MH	7	8145410.9870091	8043320.997374223	
MH	7	8145413.0356387	-16183.004265009	
MH	7	8145416.7955787	-16115.793963192	
MH	7	8145420.5955147	-16046.087926446	
MH	7	8145422.4548211	7858498.293914379	
MH	7	8145424.3554517	-15975.296587883	
MH	7	8145428.1153907	-15902.686679719	
MH	7	8145431.8753317	-15828.202099680	
MH	7	8145434.1106331	7673186.286040589	
MH	7	8145435.6352727	-15751.774506226	
MH	7	8145439.3952127	-15673.353674529	
MH	7	8145443.1551527	-15592.931758462	
MH	7	8145445.5784501	7493579.593139116	
MH	7	8145446.9150947	-15510.397637783	
MH	7	8145450.6750367	-15425.733267663	
MH	7	8145454.4349787	-15338.886154829	
MH	7	8145456.8582741	7319714.402892145	
MH	7	8145458.1949217	-15250.050524889	
MH	7	81455 1.9548637	-15158.382217763	
MH	7	81455 5.7148057	-15064.618438243	
MH	7	81455 8.1381001	7148905.314970903	
MH	7	81455 9.4747457	-14968.425524830	
MH	7	8145513.2346877	-14869.749999938	
MH	7	8145516.9946297	-14768.547572134	
MH	7	8145519.4179301	6981341.469786883	
MH	7	8145520.7545717	-14664.727034000	

Figure 15 (cont.)

MH	7	8145524.5145167	-14558.236876605
MH	7	8145528.2744597	-14449.018372653
MH	7	8145530.8857601	6814605.019683455
MH	7	8145532.0344047	-14336.992453991
MH	7	8145535.7943507	-14222.113188861
MH	7	8145539.5542967	-14104.283136425
MH	7	8145542.3535951	6651813.746672701
MH	7	8145543.3142427	-13983.450459300
MH	7	8145547.0741897	-13859.567585288
MH	7	8145550.8341377	-13732.533792613
MH	7	8145553.6334361	6495847.080016261
MH	7	8145554.5940857	-13602.290026126
MH	7	8145558.3540367	-13468.763779519
MH	7	81456 2.1139867	-13331.885498642
MH	7	81456 4.9132821	6344314.041960785
MH	7	81456 5.8739347	-13191.593175827
MH	7	81456 9.6338827	-13047.799540638
MH	7	8145613.3938307	-12900.444881855
MH	7	8145616.1931331	6197545.177123089
MH	7	8145617.1537817	-12749.447178482
MH	7	8145620.9137307	-12594.758858202
MH	7	8145624.6736827	-12436.287401556
MH	7	8145627.4729891	6055927.460570700
MH	7	8145628.4336357	-12273.993438301
MH	7	8145631.8175937	-12124.569553790
MH	7	8145656.8006431	5714590.387114810
MH	7	8145657.4792947	-10883.785433053
BH	7	8145657.4792947	-11177.128936945
MH	7	81457 1.2392527	-10685.356955347
BH	7	81457 1.2392527	-10965.440616785
MH	7	81457 4.9992117	-10482.535761116
BH	7	81457 4.9992117	-10789.370406805
MH	7	81457 8.7591717	-10275.271653532
BD	7	81457 8.7591717	-10406.458661375
BH	7	81457 8.7591717	-10588.925853012
MH	7	8145711.0884891	5564041.174498868
MH	7	8145712.5191337	-10063.540682374
BH	7	8145712.5191337	-10384.057414709
MH	7	8145716.2790977	-9847.312335968
BD	7	8145716.2790977	-9987.448490798
BH	7	8145716.2790977	-10174.793635128
MH	7	8145720.0390627	-9626.570538043
BD	7	8145720.0390627	-9771.381561637
BH	7	8145720.0390627	-9961.031495988

Figure 15 (cont.)

MH	7	8145722.3683761	5453289.173186419
MH	7	8145723.7990317	-9401.292979001
BD	7	8145723.7990317	-9550.736220479
BH	7	8145723.7990317	-9742.778215229
MH	7	8145727.0889977	-9200.437007844
BD	7	8145727.0889977	-9354.033136427
BH	7	8145727.0889977	-9548.052165329
MH	7	8145731.3189557	-8937.069553792
BD	7	8145731.3189557	-9096.087598383
BH	7	8145731.3189557	-9292.640748024
MH	7	8145733.6482721	5350155.314940820
BD	7	8145735.0789207	-8698.130249321
BH	7	8145735.0789207	-8861.911417305
BH	7	8145735.0789207	-9060.719816267
MH	7	8145738.9388877	-8454.659120738
BD	7	8145738.9388877	-8623.455380558
BH	7	8145738.9388877	-8824.287401556
MH	7	8145742.5988557	-8206.674540639
BD	7	8145742.5988557	-8390.480971097
BH	7	8145742.5988557	-8583.324803113
MH	7	8145744.9281751	5255145.669280096
MH	7	8145746.3588267	-7954.190944850
BD	7	8145746.3588267	-8132.829068213
BH	7	8145746.3588267	-8337.750656127
MH	7	8145749.4608047	-7742.543635130
BH	7	8145749.4608047	-8131.808398932
MH	7	8145753.8787677	-7435.911417305
BH	7	8145753.8787677	-7833.289698153
MH	7	8145756.2080871	5168704.527526415
MH	7	8145757.6387377	-7170.207020938
BH	7	8145757.6387377	-7574.386154860
MH	7	81458 1.3987087	-6900.222440958
BH	7	81458 1.3987087	-7311.076443552
MH	7	81458 5.1586817	-6626.022637784
BH	7	81458 5.1586817	-7043.491797864
MH	7	81458 7.4880091	5091246.948790910
MH	7	81458 8.9186567	-6347.699803144
BD	7	81458 8.9186567	-6556.983267694
BH	7	81458 8.9186567	-6771.640091836
MH	7	8145812.5446367	-6075.487532765
BD	7	8145812.5446367	-6289.579724401
BH	7	8145812.5446367	-6505.478674530
MH	7	8145816.4386167	-5779.078412056
BH	7	8145816.4386167	-6215.483267694

Figure 15 (cont.)

MH	7	8145818.7679401	5023233.398925128
MH	7	8145821.2865907	-5404.372703403
BD	7	8145821.2865907	-5630.134186327
BH	7	8145821.2865907	-5848.448818892
MH	7	8145823.9585737	-5195.242782116
BD	7	8145823.9585737	-5424.551837265
BH	7	8145823.9585737	-5643.421587914
MH	7	8145827.7185517	-4897.978674531
BD	7	8145827.7185517	-5132.214238822
BH	7	8145827.7185517	-5351.723425179
MH	7	8145830.0478801	4965042.486846300
BD	7	8145830.0478801	5012599.803130797
BH	7	8145830.0478801	4995518.011779438
MH	7	8145831.4785337	-4597.302821517
BD	7	8145831.4785337	-4836.414370060
BH	7	8145831.4785337	-5056.453412056
MH	7	8145835.2385177	-4293.425853014
BD	7	8145835.2385177	-4537.234251946
BH	7	8145835.2385177	-4757.695209950
MH	7	8145838.9985057	-3986.493438288
TF			
BD	7	8145838.9985057	-4234.887795269
BH	7	8145838.9985057	-4455.634842515
MH	7	8145841.3278321	4917039.402862144
BD	7	8145841.3278321	4961818.208648054
BH	7	8145841.3278321	4942276.738799478
MH	7	8145842.7584917	-3676.690288708
BD	7	8145842.7584917	-3929.666666657
BH	7	8145842.7584917	-4150.414041996
MH	7	8145846.5184747	-3364.213910743
BD	7	8145846.5184747	-3621.639435679
BH	7	8145846.5184747	-3842.224081352
MH	7	8145850.2784607	-3049.265091851
BD	7	8145850.2784607	-3310.935695529
BH	7	8145850.2784607	-3531.279527545
MH	7	8145854.0384497	-2732.049868762
BD	7	8145854.0384497	-2997.869094476
BH	7	8145854.0384497	-3217.771653533
MH	7	8145854.2997901	4874828.936980719
BD	7	8145854.2997901	4916232.545807969
BH	7	8145854.2997901	4893819.619384345
MH	7	8145857.7984417	-2412.770997360
BD	7	8145857.7984417	-2682.662401557
BH	7	8145857.7984417	-2901.898622036

Figure 15 (cont.)

MH	7	81459	1.5584367	-2091.681430444
BD	7	81459	1.5584367	-2365.384842515
BH	7	81459	1.5584367	-2583.833661422
MH	7	81459	5.7884277	-1728.552493438
BD	7	81459	5.7884277	-2006.360564291
BH	7	81459	5.7884277	-2223.667322829
MH	7	81459	8.3997591	4845091.108886094
BD	7	81459	8.3997591	4882650.951415570
BH	7	81459	8.3997591	4857161.154845925
MH	7	81459	9.5484177	-1404.350393690
BD	7	81459	9.5484177	-1685.668963253
BH	7	81459	9.5484177	-1901.723097108
MH	7	81459	13.3084117	-1079.074803144
BD	7	81459	13.3084117	-1363.636154853
BH	7	81459	13.3084117	-1578.378280841
MH	7	81459	17.0684087	-752.939304460
BD	7	81459	17.0684087	-1040.523950130
BH	7	81459	17.0684087	-1253.791994750
MH	7	81459	20.8284087	-426.215879263
BD	7	81459	20.8284087	-716.666994750
BH	7	81459	20.8284087	-928.166338582
MH	7	81459	21.9357471	4832679.461913471
BD	7	81459	21.9357471	4866340.157470290
BH	7	81459	21.9357471	4837948.622008667
MH	7	81459	24.5884107	-99.171587926
BD	7	81459	24.5884107	-392.191272965
BH	7	81459	24.5884107	-601.836286090
MH	7	81459	28.3784097	230.581036744
BD	7	81459	28.3784097	-64.978018373
BH	7	81459	28.3784097	-272.511482939
MH	7	81459	32.1384077	557.538713906
BD	7	81459	32.1384077	259.744094485
BH	7	81459	32.1384077	54.458989501
MH	7	81459	34.7197491	4835563.877929160
BD	7	81459	34.7197491	4865462.664031525
BH	7	81459	34.7197491	4834413.188934121
MH	7	81459	35.8984087	884.088254586
BD	7	81459	35.8984087	584.356955375
BH	7	81459	35.8984087	381.427165352
MH	7	81459	39.6584137	1209.959317572
BD	7	81459	39.6584137	909.599081360
BH	7	81459	39.6584137	708.104658786
MH	7	81459	43.8584217	1572.849081352
BD	7	81459	43.8584217	1269.870734920

Figure 15 (cont.)

BH	7	8145943.8584217	1072.327099726
MH	7	8145946.1877641	4850222.375304724
BD	7	8145946.1877641	4876679.429107042
BH	7	8145946.1877641	4843354.790006049
MH	7	8145948.0484327	1933.403871380
BD	7	8145948.0484327	1629.105314948
BH	7	8145948.0484327	1434.749999992
MH	7	8145951.8084357	2255.420275569
BD	7	8145951.8084357	1950.168963231
BH	7	8145951.8084357	1758.819225714
MH	7	8145955.5684427	2575.734251946
BD	7	8145955.5684427	2269.760498673
BH	7	8145955.5684427	2081.488845125
MH	7	8145957.6557901	4876194.192870570
BD	7	8145957.6557901	4899150.426482634
BH	7	8145957.6557901	4863629.035399981
MH	7	8145959.3284527	2894.118110210
BD	7	8145959.3284527	2587.678149581
BH	7	8145959.3284527	2402.614829376
MH	7	815 0 3.0884657	3210.351706013
BD	7	815 0 3.0884657	2903.638123333
BH	7	815 0 3.0884657	2721.910761133
MH	7	815 0 6.8484807	3524.234580040
BD	7	815 0 6.8484807	3217.569553778
BH	7	815 0 6.8484807	3039.201443538
MH	7	815 0 8.9358271	4912595.636443626
BD	7	815 0 8.9358271	4932098.687652342
BH	7	815 0 8.9358271	4894511.450103209
MH	7	815 010.6084957	3835.544947475
BD	7	815 010.6084957	3529.190288693
BH	7	815 010.6084957	3354.292650893
MH	7	815 014.3685077	4144.094160080
BD	7	815 014.3685077	3838.201443538
BH	7	815 014.3685077	3666.901902854
MH	7	815 018.1285227	4449.713910728
BD	7	815 018.1285227	4144.511154830
BH	7	815 018.1285227	3976.858923867
MH	7	815 020.2158751	4959522.047210072
BD	7	815 020.2158751	4975564.665343767
BH	7	815 020.2158751	4936068.044585705
MH	7	815 021.8885397	4752.191272944
BD	7	815 021.8885397	4447.928605738
BH	7	815 021.8885397	4283.965551136
MH	7	815 025.6485587	5051.377624631

Figure 15 (cont.)

BD	7	815	025.6485587	4748.261154800
BH	7	815	025.6485587	4588.059383154
MH	7	815	029.4085807	5347.116797834
BD	7	815	029.4085807	5045.252952695
BH	7	815	029.4085807	4888.933398932
MH	7	815	031.8719351	5018746.915984593
BD	7	815	031.8719351	5031255.183715188
BH	7	815	031.8719351	4989900.393676407
MH	7	815	033.1686047	5639.257545888
BD	7	815	033.1686047	5338.932086557
BH	7	815	033.1686047	5186.435039341
MH	7	815	036.9986227	5933.008530140
BD	7	815	036.9986227	5634.471128583
BH	7	815	036.9986227	5485.930118054
MH	7	815	040.7586437	6217.502296537
BD	7	815	040.7586437	5920.948162675
BH	7	815	040.7586437	5776.171915978
MH	7	815	043.9040091	5090921.423858105
BD	7	815	043.9040091	5099845.669249987
BH	7	815	043.9040091	5056728.182372580
MH	7	815	044.9586707	6530.578740120
BD	7	815	044.9586707	6236.347112805
BH	7	815	044.9586707	6095.967191547
MH	7	815	048.7186957	6806.551181048
BD	7	815	048.7186957	6514.459645599
BH	7	815	048.7186957	6378.108267665
MH	7	815	052.4787237	7078.336942196
BD	7	815	052.4787237	6788.751968443
BH	7	815	052.4787237	6656.162401527
MH	7	815	055.5600901	5171103.772948697
BD	7	815	055.5600901	5176625.852996039
BH	7	815	055.5600901	5131899.540648845
MH	7	815	056.2387537	7345.880905449
BD	7	815	056.2387537	7058.797900200
BH	7	815	056.2387537	6930.158792585
MH	7	815	059.9987877	7609.087926447
BD	7	815	059.9987877	7324.712926447
BH	7	815	059.9987877	7199.950459271
MH	7	815	1 3.7588157	7867.925196796
TF				
BD	7	815	1 3.7588157	7586.324146956
BH	7	815	1 3.7588157	7465.447178393
MH	7	815	1 6.8401781	5257859.514403833
BD	7	815	1 6.8401781	5260174.606292054

Figure 15 (cont.)

BH	7	815	1	6.8401781	5214070.603636997
MH	7	815	1	7.5188437	8122.322834610
BD	7	815	1	7.5188437	7843.663057655
BH	7	815	1	7.5188437	7726.558726966
MH	7	815	111.2788747	8372.245078623	
BD	7	815	111.2788747	8096.620406776	
BH	7	815	111.2788747	7983.298556387	
MH	7	815	115.0689077	8619.612860798	
BD	7	815	115.0689077	8346.987860857	
BH	7	815	115.0689077	8237.502952694	
MH	7	815	118.8289417	8860.457349002	
BD	7	815	118.8289417	8591.197178423	
BH	7	815	118.8289417	8485.350393593	
MH	7	815	119.6242891	5366496.719115616	
BD	7	815	119.6242891	5365318.110198558	
BH	7	815	119.6242891	5317782.283416079	
MH	7	815	122.6129777	9098.269356846	
BD	7	815	122.6129777	8832.220800399	
BH	7	815	122.6129777	8730.143700718	
MH	7	815	126.3730157	9330.004921137	
BD	7	815	126.3730157	9067.309711218	
BH	7	815	126.3730157	8968.818569481	
MH	7	815	130.1730557	9559.574474990	
BD	7	815	130.1730557	9300.414370000	
BH	7	815	130.1730557	9205.468503892	
MH	7	815	133.5364211	5496434.055083341	
BD	7	815	133.5364211	5491595.702086584	
BH	7	815	133.5364211	5442693.471099318	
MH	7	815	133.9330907	9782.182086526	
BD	7	815	133.9330907	9526.528215170	
BH	7	815	133.9330907	9435.012467145	
MH	7	815	137.7871267	10005.643044530	
BD	7	815	137.7871267	9753.615157365	
BH	7	815	137.7871267	9665.611876547	
MH	7	815	141.5471637	10219.110236107	
BD	7	815	141.5471637	9970.648293912	
BH	7	815	141.5471637	9885.977690219	
MH	7	815	145.3072027	10428.093175767	
BD	7	815	145.3072027	10183.123359500	
BH	7	815	145.3072027	10101.818241356	
MH	7	815	146.3205521	5625686.089202367	
BD	7	815	146.3205521	5617857.086577942	
BH	7	815	146.3205521	5567863.188934012	
MH	7	815	149.0672427	10632.640091775	

Figure 15 (cont.)

BD	7	815	149.0672427	10391.355642973
BH	7	815	149.0672427	10313.204068123
MH	7	815	152.8272847	10832.774278102
BD	7	815	152.8272847	10595.088582574
BH	7	815	152.8272847	10520.081364749
MH	7	815	156.6173287	1130.091535328
BD	7	815	156.6173287	10796.124671815
BH	7	815	156.6173287	10724.212926446
MH	7	815	157.9861881	5751823.622008629
BD	7	815	157.9861881	5741009.711272369
BH	7	815	157.9861881	5690133.136443336
MH	7	815	2.3773717	11221.512467085
BD	7	815	2.3773717	10991.209973632
BH	7	815	2.3773717	10922.284776805
MH	7	815	2.4.2014207	11411.817585169
BD	7	815	2.4.2014207	11185.169291256
BH	7	815	2.4.2014207	11119.246062933
MH	7	815	2.8.3674687	11614.185367344
BD	7	815	2.8.3674687	11391.668635069
BH	7	815	2.8.3674687	11328.860236108
MH	7	815	2.9.8208171	5886674.212554225
BD	7	815	2.9.8208171	5873193.569518377
BH	7	815	2.9.8208171	5821524.179747825
MH	7	815	212.1275117	11792.444881795
BD	7	815	212.1275117	11573.566272854
BH	7	815	212.1275117	11513.571522175
MH	7	815	215.8875547	11966.633202015
BD	7	815	215.8875547	11751.365157424
BH	7	815	215.8875547	11694.017060278
MH	7	815	220.0236047	12153.583661316
BD	7	815	220.0236047	11942.331364750
BH	7	815	220.0236047	11887.836286007
MH	7	815	221.2997951	6023854.396300691
BD	7	815	221.2997951	6007901.541960904
BH	7	815	221.2997951	5955575.688933976
MH	7	815	223.7836517	12319.373031436
BD	7	815	223.7836517	12111.740485488
BH	7	815	223.7836517	12059.779855547
MH	7	815	227.5436997	12481.275262413
BD	7	815	227.5436997	12277.156167922
BH	7	815	227.5436997	12227.710957942
MH	7	815	242.9092391	6297622.965850138
BD	7	815	242.9092391	6277370.177123344
BH	7	815	242.9092391	6224033.038024572

Figure 15 (cont.)

MH	7 815	252.1960267	13451.150590418
BD	7 815	252.1960267	13269.581036685
MH	7 815	255.2440667	13560.611876545
BD	7 815	255.2440667	13381.692585168
BH	7 815	255.2440667	13348.261482833
MH	7 815	259.0041177	13692.635170518
BD	7 815	259.0041177	13517.040682314
BH	7 815	259.0041177	13485.424868642
MH	7 815	3 2.7641687	13821.411089180
BD	7 815	3 2.7641687	13648.956364690
BH	7 815	3 2.7641687	13619.210629819
MH	7 815	3 4.5295311	6589499.901518962
BD	7 815	3 4.5295311	6565339.074767280
BH	7 815	3 4.5295311	6511265.748015802
MH	7 815	3 6.5242217	13947.020669220
BD	7 815	3 6.5242217	13777.706692813
BH	7 815	3 6.5242217	13749.744422494
MH	7 815	310.2842737	14069.526574670
BD	7 815	310.2842737	13903.421587883
BH	7 815	310.2842737	13877.105642913
MH	7 815	314.0443277	14188.993110178
BD	7 815	314.0443277	14025.900918482
BH	7 815	314.0443277	14001.330708562
MH	7 815	315.8096931	6748148.654815082
BD	7 815	315.8096931	672211.843779430
BH	7 815	315.8096931	6667728.379241424
MH	7 815	317.8043827	14305.507545827
BD	7 815	317.8043827	14145.435367344
BH	7 815	317.8043827	14122.393044530
MH	7 815	321.5644377	14419.122375249
BD	7 815	321.5644377	14262.004921137
BH	7 815	321.5644377	14240.514763652
MH	7 815	325.3244927	14529.902558981
BD	7 815	325.3244927	14375.769028781
BH	7 815	325.3244927	14355.728346346
MH	7 815	327.0898581	6910747.342498240
BD	7 815	327.0898581	6882935.334624562
BH	7 815	327.0898581	6828283.891020845
MH	7 815	329.0845497	14637.905839799
BD	7 815	329.0845497	14486.576771555
BH	7 815	329.0845497	14468.010498583
MH	7 815	332.8446067	14743.215879141
BD	7 815	332.8446067	14594.769684970
BH	7 815	332.8446067	14577.565944789

Figure 15 (cont.)

MH	7	815	337.0346707	14857.481299101
BD	7	815	337.0346707	14712.082020938
BH	7	815	337.0346707	14696.371719001
MH	7	815	338.7460331	7082608.464537685
BD	7	815	338.7460331	7053073.622008696
BH	7	815	338.7460331	6998254.921233382
MH	7	815	340.8347287	14958.344488023
BD	7	815	340.8347287	14815.736548482
BH	7	815	340.8347287	14801.311351595
MH	7	815	344.5947877	15055.630577264
BD	7	815	344.5947877	14915.664041875
BH	7	815	344.5947877	14902.468503831
MH	7	815	348.3548467	15150.477690218
BD	7	815	348.3548467	15013.160761057
TF				
BH	7	815	348.3548467	15001.161089121
MH	7	815	350.4022111	7258079.166655875
BD	7	815	350.4022111	7226923.884490048
BH	7	815	350.4022111	7171943.011748140
BD	7	815	352.1149037	15108.292650818
BH	7	815	352.1149037	15097.360564170
MH	7	815	352.1149037	15242.949146806
BD	7	815	355.8749617	15200.868110119
BH	7	815	355.8749617	15191.113845048
MH	7	815	355.8749617	15333.080380497
BD	7	815	359.6350187	15291.283792554
BH	7	815	359.6350187	15282.527558920
MH	7	815	359.6350187	15420.961614071
BD	7	815	4 3.3950767	15379.297900138
BH	7	815	4 3.3950767	15371.667978940
MH	7	815	4 3.3950767	15506.632217763
BD	7	815	4 8.0951507	15486.382873951
BH	7	815	4 8.0951507	15479.983595668
MH	7	815	4 8.0951507	15610.690288602
BD	7	815	410.9151937	15548.895013033
BH	7	815	410.9151937	15543.189960537
MH	7	815	410.9151937	15671.555117963
BD	7	815	414.6752537	15630.648293851
BH	7	815	414.6752537	15625.808726905
MH	7	815	414.6752537	15750.909120617
BD	7	815	418.4353137	15710.228674410
BH	7	815	418.4353137	15706.309383152
MH	7	815	418.4353137	15828.269028781
MH	7	816	4730.6465557	-17539.915026186

Figure 15 (cont.)

MH	7	8164734.5704857	-17499.509186265
MH	7	8164734.7698161	8636694.520933860
MH	7	8164738.1664227	-17461.455380558
MH	7	8164741.9263557	-17420.572178481
MH	7	8164745.6862897	-17378.532152174
MH	7	8164746.0496161	8640011.646911034
MH	7	8164749.4462237	-17335.312007782
MH	7	8164753.2061577	-17290.874999998
MH	7	8164756.9660917	-17245.211286066
MH	7	8164757.3294171	8444773.425170239
MH	7	81648 .7260267	-17198.274278162
MH	7	81648 4.4859627	-17150.004593133
MH	7	81648 8.2458967	-17100.393700836
MH	7	81648 8.6092211	8251104.855620212
MH	7	8164812.0058307	-17049.391732214
MH	7	8164815.7657647	-16996.995734809
MH	7	8164819.5256997	-16943.101706026
MH	7	8164819.8890251	8059156.660094117
MH	7	8164823.285633*	-16887.695866105
MH	7	8164827.0455687	-16830.776574730
MH	7	8164830.8055047	-16772.262139080
MH	7	8164831.1688321	7869046.062987763
MH	7	8164834.5654377	-16712.106627225
MH	7	8164838.3253747	-16650.266404150
MH	7	8164842.0853107	-16586.702427743
MH	7	8164842.4486411	7680961.876617118
MH	7	8164845.8452467	-16521.368110178
MH	7	8164849.6051837	-16454.212598441
MH	7	8164853.7171137	-16378.610564289
MH	7	8164853.7284521	7495052.526244734
MH	7	8164857.1250577	-16314.214566884
MH	7	81649 .8849947	-16241.262139021
MH	7	81649 4.6449327	-16166.276246605
BD	7	81649 4.6449327	-16232.407808361
MH	7	81649 5.0092651	7311539.566893685
MH	7	81649 8.4048707	-16089.182742713
BD	7	81649 8.4048707	-16157.326771615
MH	7	8164911.7888157	-16017.973097083
BD	7	8164911.7888157	-16088.047900258
BD	7	8164911.7888157	-16165.283136366
MH	7	8164916.2880811	7130592.421233359
MH	7	8164916.3007427	-15920.201115488
MH	7	8164919.6846877	-15844.732611476
BD	7	8164919.6846877	-15919.783464489

Figure 15 (cont.)

MH	7	8164923.4446287	-15758.648950098
BD	7	8164923.4446287	-15835.988188921
MH	7	8164927.2045687	-15670.154855607
BD	7	8164927.2045687	-15749.922572134
MH	7	8164927.5679001	6952442.585295983
MH	7	8164930.9645097	-15579.190616785
BD	7	8164930.9645097	-15661.680774151
BH	7	8164930.9645097	-15745.266732214
MH	7	8164934.7244517	-15485.679790018
BD	7	8164934.7244517	-15570.657480238
BH	7	8164934.7244517	-15655.693897603
MH	7	8164937.9204027	-15404.130577383
BH	7	8164937.9204027	-15577.519028840
MH	7	8164938.8477221	6777355.314909954
MH	7	8164942.5963317	-15281.318569540
BD	7	8164942.5963317	-15372.062992035
BH	7	8164942.5963317	-15459.887467204
MH	7	8164947.0782627	-15159.574146925
BD	7	8164947.0782627	-15254.576115427
MH	7	8164949.4822247	-15092.621719060
BD	7	8164949.4822247	-15188.787729619
MH	7	8164950.1275481	6605573.326720275
MH	7	8164953.8061557	-14969.174868761
BD	7	8164953.8061557	-15068.604330717
BH	7	8164953.8061557	-15160.727034031
MH	7	8164957.2841027	-14866.995078682
BD	7	8164957.2841027	-14969.642060278
BH	7	8164957.2841027	-15062.845800458
MH	7	81650.8960467	-14758.098753212
BD	7	81650.8960467	-14863.678477584
BH	7	81650.8960467	-14958.409776865
MH	7	81650 1.4073771	6437383.792601565
MH	7	81650 4.8039867	-14636.990813612
TR			
END			

Section 4.

SAMPLE OUTPUT

4.0 This section presents the actual output from the test cases described in Section 3.6.4 whose input is listed in Figures 13, 14, and 15. Each test case is covered separately and the code numbers next to certain sections of the output correspond to the numbered paragraphs of the explanation that follows.

Due to lack of space only pieces of the total output are shown; however, the full actual output is available.

4.1 Trajectory Prediction Output

The following sequenced paragraphs describe the different parts of trajectory prediction test case output shown in Figures 16 to 19.

1. The constants used in the program (c, INTEG, NUMB, IFLAG) are printed out here in exact input card image.
2. These numbers are the geopotential inputs printed out exactly as read in.
3. The last part of the input data printed out is all the trajectory-only input.
4. Program name and identification of the particular Aerospace version.
5. The Epoch time for this run.
6. Indicators printed out giving the logical flow from segment to segment and old and new function numbers.
7. Card image of last END card in the deck.
8. Trajectory initial conditions in three coordinate systems. Initial-condition values as shown are the result of transformations which have been applied to the input values. The transformation for the input coordinate set (α , δ , β , A, r, v in this case) consists of conversion from decimal to octal numbers,

conversion of units from feet, degrees, and seconds to earth radii, radians, and minutes, and performance of corresponding inverse conversions for output. The two other types of elements sets also require accomplishment of coordinate-system transformations in addition to the number- and units-systems conversions noted above. Accuracy of the values as printed therefore is subject to numerical roundoff errors.

Quantities in the left-hand column are position and velocity components in the basic vernal equinox coordinate system, with units of feet and of feet per second. The center column gives the usual ADBARV spherical system coordinates (i.e., Type-2 initial conditions in units of feet, feet per second, and degrees). The right-hand column from top to bottom contains orbit semi-major axis, eccentricity, inclination, right ascension of ascending node, argument of perigee, and time of last perigee passage in minutes from midnight of epoch day. Other units are feet and degrees.

9. Identification of atmosphere model to be used in computing drag force. LOCKHEED and ARDC 1959 refer to the Lockheed-Jacchia and the ARDC 1959 model atmospheres, respectively. Reciprocal of ballistic coefficient, $C_D A/W$. Ballistic coefficient, $W/C_D A$. d_1 and d_2 are values of certain constants in the Lockheed-Jacchia atmosphere density expressions.
10. The product GM , or the universal gravitational constant times the mass of the earth (frequently designated by μ), expressed in units of earth radii cubed per minute squared. Unitless coefficients of the zonal harmonic terms in the earth potential field expansion (i.e., J_2 through J_{15}). Coefficients and longitudinal arguments of tesseral and sectorial terms in earth potential field expansion, with J indicating a coefficient and L an argument in degrees. The digits following J or L are the

associated Legendre polynomial degree and order, respectively.

11. Names of solar-system bodies included in computation of perturbative accelerations. In this case none are used.
12. Trajectory method indicator. The Cowell formulation of the equations of motion is the only trajectory method available in the present TRACE-D program.

Numerical integration parameters. The Gauss-Jackson method (subroutine DE02) is the only integration method available in the present TRACE-D program.

13. The indices N_1 and N_2 input in the IOB array respectively indicate the highest-degree zonal term and the highest-degree and -order tesseral term. No term higher than those indicated by these input numbers will be computed, regardless of the model coefficients and arguments that are input to the physical constants region.
14. Physical constants and units conversion factors. Decimal and octal equivalents are given for the following quantities.

- | | | |
|----|-----------------------|--|
| a. | OMEGA E(ω_e) | Earth rotation rate in radians per minute, |
| b. | ALPHA G(α_g) | Right ascension of Greenwich at midnight of the day of epoch in radians, |
| c. | FT/KM | Feet per kilometer, |
| d. | E.R/A.U. | Earth radii per astronomical unit, |
| e. | I-O, DISTANCE | Input/output units conversion factor in feet per earth radius, |
| f. | G | Acceleration due to gravity in feet per second squared, |
| g. | DEG/SEC//
RAD/MIN | Units conversion factor in degrees per second/radians per minute, |

- | | | |
|----|------------------------|---|
| h. | RELATIVE
MASS (SUN) | Mass of sun relative to
mass of earth, |
| i | (VENUS) | Mass of Venus relative to
mass of earth, |
| j. | (JUPITER) | Mass of Jupiter relative
to mass of earth, |
| k. | GM | Earth gravitational constant
(μ) in earth radii cubed per
minute squared, |
| l. | EARTH
RADIUS-FT | Number of feet per earth radius
for internal calculations
(rather than I-0), |
| m. | N.M/E.R | Number of nautical miles per
earth radius, |
| n. | I-0, VELOCITY | Conversion factor for input/
output in feet per second/
earth radii per minute, |
| o. | FT/SEC//
E.R./MIN. | Units conversion factor in
feet per second/earth radii
per minute, |
| p. | 1/EPS | Earth flattening (reciprocal
of earth ellipticity), |
| q. | (MOON) | Mass of moon relative to
mass of earth, |
| r. | (MARS) | Mass of Mars relative to
mass of earth, |
| s. | (SATURN) | Mass of Saturn relative to
mass of earth. |
15. Date and time of day (Greenwich Mean Time) with which the quantities in the print block following are to be associated.
 16. Minutes from epoch, minutes from midnight of current day, system time (i.e.; seconds from midnight of current day), and current integration step size in minutes.
 17. x, y, z, r: Components and magnitude of the radius vector from geocenter to satellite in the basic coordinate system in units of feet.
 18. \dot{x} , \dot{y} , \dot{z} , v: Components and magnitude of the inertial velocity vector with respect to the basic coordinate

system in units of feet per second.

19. Geodetic latitude, in degrees, of the point where the radius vector intersects the ellipsoidal surface of the earth, geographic longitude measured east from Greenwich in degrees, altitude of the satellite above the oblate earth in nautical miles, and geodetic latitude of the subvehicle point in degrees. All latitude quantities are considered positive north of the equator and negative south of the equator.
20. α , δ , β , A: Right ascension of satellite position, declination of satellite position, flight path angle, and inertial azimuth of velocity vector in units of degrees.
21. Revolution number, nodal period in minutes, nodal period decay rate in minutes per revolution, and nodal regression rate in degrees per revolution. Due to the fact that the nodal period is calculated by simple subtraction of ascending-node crossing times, this quantity cannot be determined until two ascending node crossings have been detected. Also, since the nodal-period decay rate is computed by differencing the nodal-period values at successive ascending nodes, this rate cannot be calculated until three ascending nodes have been crossed. The nodal regression rate is computed by differencing values of right ascension at successive ascending nodes.

4.2 Observation Generation Sample Output

Figures 20 to 24 contain the output from the observation generation test case. There are numbered descriptions corresponding to the number codes on the output; however, only the output that has not been previously described in Section 4.1 is covered here. Therefore, Figures 20 and 21 are included for completeness but need no further description (see Section 4.1 for this information).

1. Bias inputs for data and last END card.
2. Sigmas. In the case of a data generation run, the sigma table is used for the purpose of specifying the standard deviation of random noise which is to be applied to the generated data. Interpretation of the printed output shown is otherwise the same as described under section for Data Generation.
3. Station locations, latitude, longitude, and altitude.

4. Data Limit Specifications. The eight columns from left to right contain station identification, data interval, minimum elevation angle, maximum elevation angle, maximum range in nautical miles, and data-generation start and stop times in days, hours, and minutes from midnight of epoch day.

The information shown indicates that the following specifications have been given to the program:

- a. Observations are to be generated for station AA at 15-second intervals whenever the computed local elevation angle is above zero degrees.
- b. No maximum elevation angle is assumed and no maximum range is to be considered (data generated for all ranges and for all elevation angles greater than zero).
- c. Station AA is assumed to be active during the time interval from epoch until a time 24 hours after midnight of epoch day.

In the case of this particular data generation run, the corresponding Specification-I input items for Stations BB through FF are identical to those for Station AA. However, this need not be true in general, inasmuch as each station is independent of the others with respect to these input items.

5. Parameter indication. The message indicates that the range bias parameter has been selected for Station BB. In the case of a data generation run, radar parameters are selected only for the purpose of applying biases to the generated data, in this case a range bias on Station BB data. The message alluding to the correction of parameters therefore should be ignored.
6. Data Types. These headings define the format of the table appearing beneath them. The purpose of this table is to define the types of data which are to be generated for each station. Except for the station-identification column header, which is printed vertically, the headings appear in two horizontal rows, with the top row displaying the symbols RANGE on the left and LONG. on the right and the second row the symbols SUR.R on the left and U, V on the right. The individual headings are interpreted in accordance with the following:

<u>Heading</u>	<u>Description or Symbol</u>	<u>Units</u>
RANGE	Range	n mi
AZMTH	Local azimuth angle	deg
ELEV.	Local elevation angle	deg
R. DOT	Range rate	ft/sec
P. DOT	Range-rate difference	ft/sec
Q. DOT	Range-rate difference	ft/sec
P	Range difference	ft
Q	Range difference	ft
AZ. DT	Rate of change of local azimuth	deg/sec
E. DOT	Rate of change of local elevation	deg/sec
R. DDT	Second time derivative of range	ft/sec ²
MU. VIS	Mutual visibility	(indicator)
LAT	Latitude of sub-vehicle point	deg
LONG	Longitude of sub-vehicle point	deg
SUR. R	Surface range, station to sub-vehicle point	n mi
HIGHT	Altitude above oblate earth	n mi
DOPLR	Doppler frequency shift	cps
LOOK	Look angle	deg
VARI	Variances	Same as corresp. observations
KAPPA	Angle between radius vector and local vertical	deg
ASPCT	Aspect angles	deg
ATTEN	Signal attenuation	db
X, Y, Z	\hat{x} , \hat{y} , \hat{z}	n mi
T-R, D	Topocentric right ascension and declination	deg
HR, ANG	Topocentric hour angle	deg
U, V	Horizon-scanner angles, u, v	deg

The two horizontal lines associated with each station are the line containing the station-identification symbol and the line immediately below it. An X on the first line of a Y on the second line indicate that the corresponding quantity as defined by the table header is to be generated. In the present example, the indicated data types for Station AA are range, azimuth, elevation, range rate, height (altitude), \hat{x} , \hat{y} , \hat{z} , topocentric hour angle, and horizon-sensor angles u and v .

7. Segment transfer messages.
8. Rise message. The time when the satellite becomes visible from a particular station (at the specified minimum elevation angle) is obtained by interpolation and printed in the manner shown along with the local azimuth angle for the corresponding time.
9. Time corresponding to generated data. The time shown is to be associated with the data quantities appearing on the line to the right of the time printout and on the line following. The time is given both in hours (0 through 24) and minutes of the day as identified at the top of the output page, as well as in minutes from start (i.e., minutes from epoch). In the case of the particular output shown, time from start corresponds to the time of day because the epoch chosen for the run happened to be midnight.
10. Maximum elevation point. The time when the elevation angle reaches its maximum is obtained by interpolation and printed along with the corresponding values for the elevation and azimuth angles in the manner shown.
11. Set message. When the time at which the elevation angle reaches the specified minimum from above is obtained by interpolation, the print shown at this position occurs.
12. Duration message. After each pass, a message is printed giving the time in minutes during which the elevation angle was above the input minimum value and the range was below the input maximum value.

4.3 Orbit Determination Sample Output

This section contains the output from the orbit determination test case. Here also, only that output which has not been previously described is considered, although all of the output is shown in Figures 25 through 31.

1. The station location card quantities, refraction indicator, sigma set, latitude, longitude, and altitude.
2. Each line is the printout of one observation card. Given are the date, station ID, both the type and set number for these measurements, and the three measurements. In this case Line 1 has a Range Rate measurement only.
3. This line contains a Range measurement only.
4. Indicates those parameters chosen in input to be estimated.
5. In this case, the spherical set of initial conditions, drag coefficient, GM, J_2 and J_3 are to be estimated.
6. The number of iterations after which the program stops. In this case, one only.
7. A count of the parameters to be estimated.
8. A count of the number of observation cards read.
9. A total obtained by assuming three observations per cards.
10. A count of all the sites entered on station location cards.
11. The number of locations that all the data has been packed into and then stored on scratch tape.
12. The number of flocks (TF and TR cards) read.
13. Segment transfer messages.
14. Differential correction bounds. This sequence corresponds to the previously described sequence of the parameter indications.
15. Weighting sigmas. The observation type number and the value of the weighting value are shown.
16. Definition of current orbit. For each iteration the current values for the parameters are used to compute the quantities shown
17. Node print. Each time the integrated trajectory crosses the equator (as determined by interpolation between integration steps) the date, time in minutes from midnight of epoch, and the rectangular elements (x , y , z , \dot{x} , \dot{y} , \dot{z} ,) in units

of earth radii and earth radii per minute are printed. The numerical integration interval for each satellite begins at epoch and ends at the time of the latest observation for that satellite. A message is printed each time any of the events of equator crossing, start of thrusting, end of thrusting, or orbit adjust are detected during the integration interval.

18. Station identification and system time of residuals. These are to be associated with all residuals which appear on the same line. It should be noted that system time is defined as seconds from midnight of the current day.
19. Residuals. These are unnormalized differences between the input observations (as modified by bias or refraction corrections) and corresponding values for the same observation types computed from the integrated trajectory position at the observation times. Up to six residuals for the same time are printed on one line. The observation type is indicated in parentheses immediately following the residual value in each case. Note that residuals appear for the unweighted as well as for the weighted observations.

Identification of the foregoing observation-type indicators with observation descriptions or symbols defined elsewhere in this report is in accordance with the following:

<u>Indicator</u>	<u>Description or Symbol</u>	<u>Unit</u>
R	Range	ft
A	Azimuth	deg
E	Elevation	deg
TR	Topocentric right ascension	deg
TD	Topocentric declination	deg
HA	Topocentric hour angle	deg
GR	Geocentric right ascension	deg
GD	Geocentric declination	deg
U	Horizon scanner in-plane angle	deg
V	Horizon scanner cross-plane angle	deg
H	Altitude (h)	ft

<u>Indicator</u>	<u>Description or Symbol</u>	<u>Unit</u>
X	\hat{x}	ft
Y	\hat{y}	ft
Z	\hat{z}	ft
R	Range	ft
P	Range difference	ft
Q	Range difference	ft
RD	Range rate	ft/sec
PD	Range-rate difference	ft/sec
QD	Range-rate difference	ft/sec

20. Observation time. The time identified in Item 2 in terms of seconds from midnight is given in alternate form, wherein the day of the month and the hour and minute of the day are given as integers and seconds are given to two decimal places.
21. RMS summary of residuals. The root-mean-square of the residuals for each type of observation from each station is computed by the residuals editor and the result is printed at this location. Included are the station identification, number of residuals included in the RMS (i.e., the total number for that station and type minus the number deleted by the editor on this iteration), RMS, and the RMS divided by input weighting sigma. The observation-type indicators are the same as those used in the residuals print output. Units are feet, degrees and seconds. Interpretation of the range-rate summary for station MH is that 206 range rate measurements were used to compute the rms which equals 1.61216 feet per second. RMS over sigma is equal to 26.6209 feet per second.
22. Iteration number. TRACE-D performs the tracking, or orbit determination function, by computing series of differential corrections to the parameters selected by the user. The iteration number is advanced each time the process of computing a set is repeated. The number may be interpreted as an indication of the number of times the trajectory-integration/least-squares process has been performed.
23. Observation count. The number of individual observations included in the current least-squares computation is indicated.

24. Convergence indicator. If the weighted RMS for all residuals for the current iteration is less than that for any previous iteration, then the fitting process is converging and the message shown is printed. If the RMS obtained on the current iteration is greater than the smallest RMS obtained on previous iterations, the message

CURRENT ITERATION IS NOT GOOD

(RMS = 0.xxxxxxxxx xx)

is printed in this position.

25. Current solution. If the iteration is successful (i.e., the overall RMS has been lowered), indicated values are the parameter values used in the trajectory, partial derivative, and residuals computations which have just been completed. In the case of Iteration No. 1, they are the input values of the parameters.

If the iteration is bad, the words

GO BACK TO

are printed, and the values of the parameters which so far have produced the lowest RMS are recovered from memory and printed at this point. Parameter names are generally self-explanatory, with the possible exceptions of the multiple-vehicle elements. The satellite number is printed before the element name for Satellites 2 through 6.

26. Current solution in octal digits and machine units. These numbers corresponding to those described in Item 30 are given both in the octal mode and in the units used for internal computations. Use of these quantities permits bypassing units and number-system conversions during input and output.
27. RMS. This is the quantity which is to be minimized in the tracking or orbit determination process and is the root-mean-square of the normalized residuals included in the least-squares calculations on the current iteration.
28. Corrections. The result of solving the system of normal equations associated with the parameter which occupies the corresponding position in the current solution block. Units are feet, degrees, and seconds.
29. Bounds. Current values of the numbers used to limit the size of corrections. In general, these bounds are

automatically increased on a good iteration and automatically decreased on a bad one.

30. Bounding indicator. This message will be either

HITTING BOUNDS

or

NOT HITTING BOUNDS

The first message indicates that the magnitudes of the corrections have been controlled by solving the system in such a way that the constraint implied by the bounds is satisfied, and the latter that the normal equations have been solved without applying the bounds.

31. Next solution. Each value is the sum of the parameter value given in the corresponding position under "current solution" and the associated correction. These are the parameter values which will be used for the next solution.
32. Next solution in octal mode and units of earth radii, radians, and minutes.
33. Predicted RMS. If the fitting process is converging in a completely linear fashion, this will be the RMS on the next iteration. The comparison of this number with the current RMS (see Item 32) may be used to measure the degree to which the process has already converged.
34. Sigma of parameters divided by sigma of the normalized observations. The numbers given are the square roots of the diagonal elements of the inverse normal matrix. If certain assumptions are made about the characteristics of the observation set, the numbers may then be taken as the variances on the parameter solutions.
35. Correlation matrix, correlation coefficients for the parameter set. These values are computed directly from the covariance matrix (i.e., the inverse normal matrix). Rows and columns are in the same sequence as the Item 34 data.
36. This is the upper half of the normal matrix.
37. This is the lower half of the inverse normal matrix.

Figure 16. Trajectory Prediction Output Listing of Input

TRACE-D STANDARD INTEGRATION CONSTANTS													BASIC INPUT CARD	
11	1	12	2	13	0								1	2
4	1	5	1	11	1.00002516								3	
23	1	-9											4	
26	1												5	
30	1	31	.015625	32	64	33	1	-7					6	
134	4	135	1	37	.0001	38	0.						7	
40	2820.18012	141	1										8	
TRACE-D STANDARD PHYSICAL CONSTANTS 10/ 1/65													BASIC INPUT CARD	
1	.437526904	-2	2	.5530370	-2	6	.5						9	
8	.437526904	-2	9	1.	10	10		(1)					10	
13	3280.8399	14	57.2957795	15	20925738								11	
16	332951.3	17	.01229853	18	.814979								12	
19	.107821	20	317.887	21	95.129								13	
22	23454.865	23	3443.3355	24	20925738								14	
25	348762.3	26	32.174	30	348762.3								15	
31	1.5	32	1.0471976	33	3.14159265								16	
34	298.3	35	300003.	36	82505.922								17	
NUMB 42 3443.9336													BASIC INPUT CARD	
IIFLAG 128 0													BASIC INPUT CARD	
1108	14	12	15	13	14	14	15						20	
ORJZ 1													BASIC INPUT CARD	
2	1082.645	-6	3	-2.546	-6	4	-1.649	-6					21	
5	-.213	-6											22	
6	.646	-6											23	
7	-.333	-6	8	-.270	-6								24	
9	-.053	-6											25	
10	-.054	-6	11	.302	-6	12	-.357	-6	13	-.114	-6		26	
14	.179	-6											27	
ORJZ													BASIC INPUT CARD	
2	.1765980	-5	3	.2110765	-5	4	.3108429	-6	5	.2390598	-6		28	
ORJZ													BASIC INPUT CARD	
2	.1765980	-5	3	.2110765	-5	4	.3108429	-6	5	.2390598	-6		29	
ORJZ													BASIC INPUT CARD	
2	.1765980	-5	3	.2110765	-5	4	.3108429	-6	5	.2390598	-6		30	
ORJZ													BASIC INPUT CARD	
2	.1765980	-5	3	.2110765	-5	4	.3108429	-6	5	.2390598	-6		31	

6	.7017339	-6 7	.1652	-6 8	.521C912	-7 9	.4986992	-8	BASIC INPUT CARD	32
10	.1111605	-6 11	.1088C12	-6 12	.1717943	-7 13	.2122685	-8	BASIC INPUT CARD	33
14	.1507404	-8 15	.4264694	-7 16	.4633369	-7 17	.1291007	-8	BASIC INPUT CARD	34
18	.1967936	-8 19	.4477079	-9 20	.3729502	J0 21	.1839230	-6	BASIC INPUT CARD	35
22	.3972437	-7 23	.3543C592	-8 24	.3887152	-9 25	.3299649	J0	BASIC INPUT CARD	36
26	.1513140	J0 27	.2052417	J1 28	.6820109	-7 29	.3849809	-8	BASIC INPUT CARD	37
30	.3762496	-9 31	.2771455	-9 32	.2341330	J0 33	.8894014	J1	BASIC INPUT CARD	38
34	.1641761	J2 35	.3418347	J2 36	.7842382	-7 37	.2440136	-8	BASIC INPUT CARD	39
44	.8609215	J4 45	.1013471	-6 46	.6724120	-8 47	.4173952	-9	BASIC INPUT CARD	40
48	.7857074	J0 55	.3251625	-7 66	.1006553	-6 67	.4704701	-8	BASIC INPUT CARD	41
77	.2783799	J8							BASIC INPUT CARD	42
89	.1717906	J8 90	.3549629	J9 91	.8360589	-8			BASIC INPUT CARD	43
101	.1059143	K0							BASIC INPUT CARD	44
102	.1326684	J9 104	.1974783	K1					BASIC INPUT CARD	45
113	.5398041	J8 116	.1393759	J9 117	.1472896	K0 118	.5702221	K2	BASIC INPUT CARD	46
OBLT										
2	.165.2042	3	.7.623267	4	.161.8799	5	.23.63307		BASIC INPUT CARD	48
6	.219.3494	7	.31.73482	8	.115.8047	9	.25.74411		BASIC INPUT CARD	49
10	.232.5121	11	.169.9065	12	.59.74292	13	.41.60563		BASIC INPUT CARD	50
14	.56.95252	15	.209.876	16	.140.3382	17	.50.04699		BASIC INPUT CARD	51
18	.66.28621	19	.47.13021	20	.42.58828	21	.38.37493		BASIC INPUT CARD	52
22	.12.06147	23	.1.37273	24	.53.46592	25	.7.078959		BASIC INPUT CARD	53
26	.27.20422	27	.8.598698	28	.139.0856	29	.28.15497		BASIC INPUT CARD	54
30	.57.94327	31	.45.80993	32	.22.83747	33	.15.51001		BASIC INPUT CARD	55
34	.15.09665	35	.19.70539	36	.5.856014	37	.48.25990		BASIC INPUT CARD	56
44	.13.95194	45	.309.8056	46	.100.9007	47	.68.25838		BASIC INPUT CARD	57
48	.59.07748	55	.164.1975	66	.203.3371	67	.91.41733		BASIC INPUT CARD	58
77	.14.87681								BASIC INPUT CARD	59
89	.11.44440	90	.9.804658	91	.160.5400				BASIC INPUT CARD	60
101	.30.31227	102	.23.80277	104	.13.72105	113	.27.04833		BASIC INPUT CARD	61
116	.15.65423								BASIC INPUT CARD	62
117	.16.80139	118	.20.10848						BASIC INPUT CARD	63
119									BASIC INPUT CARD	64

Figure 16 (cont.)

DTIC 3

IIC1YP2

16 358.2

2 -25.5

3 90.35

4 47.18

5 22999226.

6 24797.530

IPRIMO

12 1

5 60.

6 30.

DRAG .008

12 1

3 6.83

YEAR 1967

IDAY 8

HR 15.

UPREDEF X

IPTAPE4

END

BASIC INPUT CARD 65

BASIC INPUT CARD 66

BASIC INPUT CARD 67

BASIC INPUT CARD 68

BASIC INPUT CARD 69

BASIC INPUT CARD 70

BASIC INPUT CARD 71

BASIC INPUT CARD 72

BASIC INPUT CARD 73

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BASIC INPUT CARD 75

BASIC INPUT CARD 76

BASIC INPUT CARD 77

BASIC INPUT CARD 78

BASIC INPUT CARD 79

BASIC INPUT CARD 80

BASIC INPUT CARD 81

BASIC INPUT CARD 82

BASIC INPUT CARD 83

BASIC INPUT CARD 84

(3)

7 90.

4 -15.684

IMNTH 7

TZNE 0.

MIN 0.

SEC 0.

Figure 16 (cont.)

Figure 18. Initial Information

BASIC INPUT CARD 1 (7)

END

INITIAL CONDITIONS

X =	.20748520E+08	ALPHA =	.35820000E+03	A =	.23107813E+08
Y =	-.65204847E+06	DELTA =	-.25500000E+02	C =	.77068993E-02
Z =	-.99014220E+07	BETA =	.90350000E+02	I =	.14384E+02
U007 =	.76871283E+04	AZ =	.47180000E+02	O =	.23118841E+02
U008 =	.17955868E+05	R =	.22999226E+08	U =	.17721554E+02
U009 =	.19277888E+05	V =	.24797530E+05	T =	.81613989E+03

(8)

ATMOSPHERE =	LOCKNEED	CDM/W =	.80000000E-02	W/CDA =	.12500000E+03
D1 =	.68300000E+01	D2 =	-.15684000E+02		

(9)

EARTH MODEL

G1 =	.55303700E-02	J2 =	.10826450E-02	J3 =	-.25460000E-05	J4 =	-.16490000E-05	J5 =	-.21000000E-06
J6 =	.64600000E-06	J7 =	-.33300000E-06	J8 =	-.27000000E-06	J9 =	-.53000000E-07	J10 =	-.54000000E-07
J11 =	.30200000E-06	J12 =	-.37000000E-06	J13 =	-.11400000E-06	J14 =	-.17900000E-06	J15 =	-.00000000E-00
J21 =	.00000000E-00	L21 =	.00000000E-00	J32 =	.10880120E-06	L32 =	.16990650E+03		
J22 =	.17659800E-05	L22 =	.16520420E+03	J33 =	.17179430E-07	L33 =	.59742920E+02		
J31 =	.21107650E-05	L31 =	.78232670E+01	J34 =	.21226850E-08	L34 =	.41605630E+02		
J32 =	.31084290E-06	L32 =	.16187990E+03	J35 =	.15074040E-08	L35 =	.56952520E+02		
J33 =	.23905980E-06	L33 =	.23633070E+02	J61 =	.42646940E-07	L61 =	.20987600E+03		
J41 =	.70171330E-06	L41 =	.21934940E+03	J62 =	.46333690E-07	L62 =	.14033820E+03		
J42 =	.16520800E-06	L42 =	.31734820E+02	J63 =	.12910070E-08	L63 =	.50046980E+02		
J43 =	.32109120E-07	L43 =	.11580470E+03	J64 =	.19679360E-08	L64 =	.66286210E+02		
J44 =	.49969920E-08	L44 =	.25744110E+02	J65 =	.44770790E-09	L65 =	.47130210E+02		
J51 =	.11116050E-06	L51 =	.23251210E+03	J66 =	.37295020E-10	L66 =	.42588280E+02		

(10)

J71 =	.18323300E-06	L71 =	.38374930E+02	J125 =	-.00000000E-00	L125 =	-.00000000E-00
J72 =	.39724370E-07	L72 =	.12061470E+02	J126 =	-.00000000E-00	L126 =	-.00000000E-00
J73 =	.35430592E-00	L73 =	.13727300E+01	J127 =	-.00000000E-00	L127 =	-.00000000E-00
J74 =	.38871520E-04	L74 =	.53465920E+02	J128 =	-.00000000E-00	L128 =	-.00000000E-00
J75 =	.32996490E-10	L75 =	.70789590E+01	J129 =	-.00000000E-00	L129 =	-.00000000E-00
J76 =	.15151400E-10	L76 =	.27204220E+02	J1210 =	-.00000000E-00	L1210 =	-.00000000E-00
J77 =	.20524170E-11	L77 =	.85986980E+01	J1211 =	-.00000000E-00	L1211 =	-.00000000E-00
J81 =	.68201090E-07	L81 =	.13908580E+03	J1212 =	-.27837990E-18	L1212 =	.14876810E+02
J82 =	.3848990E-08	L82 =	.28154970E+02	J131 =	-.00000000E-00	L131 =	-.00000000E-00
J83 =	.37624960E-09	L83 =	.57943270E+02	J132 =	-.00000000E-00	L132 =	-.00000000E-00
J84 =	.27714550E-09	L84 =	.45809930E+02	J133 =	-.00000000E-00	L133 =	-.00000000E-00
J85 =	.23413300E-10	L85 =	.22837470E+02	J134 =	-.00000000E-00	L134 =	-.00000000E-00
J86 =	.88940140E-11	L86 =	.15510010E+02	J135 =	-.00000000E-00	L135 =	-.00000000E-00
J87 =	.16417610E-12	L87 =	.15096680E+02	J136 =	-.00000000E-00	L136 =	-.00000000E-00
J88 =	.34183470E-12	L88 =	.19705390E+01	J137 =	-.00000000E-00	L137 =	-.00000000E-00
J89 =	.76423820E-07	L89 =	.58560140E+01	J138 =	-.00000000E-00	L138 =	-.00000000E-00
J92 =	.24401360E-08	L92 =	.48259900E+02	J139 =	-.00000000E-00	L139 =	-.00000000E-00
J93 =	.00000000E-00	L93 =	.00000000E-00	J1310 =	-.00000000E-00	L1310 =	-.00000000E-00
J94 =	.00000000E-00	L94 =	.00000000E-00	J1311 =	-.00000000E-00	L1311 =	-.00000000E-00
J95 =	.00000000E-00	L95 =	.00000000E-00	J1312 =	-.00000000E-00	L1312 =	-.00000000E-00
J96 =	.00000000E-00	L96 =	.00000000E-00	J1313 =	.35494290E-19	L1313 =	.78046580E+01
J97 =	.00000000E-00	L97 =	.00000000E-00	J141 =	.83603890E-08	L141 =	.16054000E+03
J98 =	.00000000E-00	L98 =	.00000000E-00	J142 =	-.00000000E-00	L142 =	-.00000000E-00
J99 =	.00000000E-00	L99 =	.00000000E-00	J143 =	-.00000000E-00	L143 =	-.00000000E-00
J101 =	.86092150E-14	L101 =	.13951940E+02	J144 =	-.00000000E-00	L144 =	-.00000000E-00
J102 =	.78724120E-08	L102 =	.30580540E+03	J145 =	-.00000000E-00	L145 =	-.00000000E-00
J103 =	.4173520E-09	L103 =	.10090070E+03	J146 =	-.00000000E-00	L146 =	-.00000000E-00
J104 =	.7852760E-10	L104 =	.68256360E+02	J147 =	-.00000000E-00	L147 =	-.00000000E-00

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J10 5= .0000000E 00 J10 5= .0000000E 00 J14 8= .0000000E 00 L14 8= .0000000E 00
J10 6= .0000000E 00 J10 6= .0000000E 00 J14 9= .0000000E 00 L14 9= .0000000E 00
J10 7= .0000000E 00 J10 7= .0000000E 00 J14 10= .0000000E 00 L14 10= .0000000E 00
J10 8= .0000000E 00 J10 8= .0000000E 00 J14 11= .0000000E 00 L14 11= .0000000E 00
J10 9= .0000000E 00 J10 9= .0000000E 00 J14 12= .0000000E 00 L14 12= .0000000E 00
J10 10= .0000000E 00 J10 10= .0000000E 00 J14 13= .0000000E 00 L14 13= .0000000E 00
J11 1= .32516250E-07 J11 1= .16419750E+03 J14 14= .1974730E-21 L14 14= .13741050E+02
J11 2= .0000000E 00 J11 2= .0000000E 00 J15 1= .0000000E 00 L15 1= .0000000E 00
J11 3= .0000000E 00 J11 3= .0000000E 00 J15 2= .0000000E 00 L15 2= .0000000E 00
J11 4= .0000000E 00 J11 4= .0000000E 00 J15 3= .0000000E 00 L15 3= .0000000E 00
J11 5= .0000000E 00 J11 5= .0000000E 00 J15 4= .0000000E 00 L15 4= .0000000E 00
J11 6= .0000000E 00 J11 6= .0000000E 00 J15 5= .0000000E 00 L15 5= .0000000E 00
J11 7= .0000000E 00 J11 7= .0000000E 00 J15 6= .0000000E 00 L15 6= .0000000E 00
J11 8= .0000000E 00 J11 8= .0000000E 00 J15 7= .0000000E 00 L15 7= .0000000E 00
J11 9= .0000000E 00 J11 9= .0000000E 00 J15 8= .0000000E 00 L15 8= .0000000E 00
J11 10= .0000000E 00 J11 10= .0000000E 00 J15 9= .0000000E 00 L15 9= .0000000E 00
J11 11= .0000000E 00 J11 11= .0000000E 00 J15 10= .0000000E 00 L15 10= .0000000E 00
J12 1= .1006930E-06 J12 1= .2053970E+03 J15 11= .0000000E 00 L15 11= .0000000E 00
J12 2= .47047010E-08 J12 2= .91471730E+02 J15 12= .13937590E-19 L15 12= .15654230E+02
J12 3= .0000000E 00 J12 3= .0000000E 00 J15 13= .14928960E-20 L15 13= .16801390E+02
J12 4= .0000000E 00 J12 4= .0000000E 00 J15 14= .57022210E-22 L15 14= .20108480E+02
J12 5= .0000000E 00 J12 5= .0000000E 00 J15 15= .0000000E 00 L15 15= .0000000E 00

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(18)

THE FOLLOWING BODIES ARE USED FOR PLANETARY PERTURBATIONS (11)

NONE

FORMULATION CONELL FEQS OF MOTION

DIFFERENTIAL EQUATION SUBROUTINE E BAR= .1000E-09 A= 1.000 RATIO OF CONELL STEP TO RUNGE KUTTA 4 (12)

STEP SIZE GAUSS-JACKSON INITIAL= .1000E+01 MINIMUM= .1562E-01 MAXIMUM= .4600E+02

DO NOT RECOMPUTE PERTURBATIONS FOR CORRECTOR

EQUATIONS OF MOTION USE N1=14 N2=15 (13)

CONSTANTS		DECIMAL	DECIMAL	DECIMAL
OMEGA C	DECIMAL	325340203260	CM	66221635100
ALPHA G	DECIMAL	49787546E+01		
PERM	DECIMAL	32808399E+04	EARTH RADIUS - FT	4520000000000
E.R./A.U.	DECIMAL	23454865E+05	N.M./E.R.	737510377420
I-O, DISTANCE	DECIMAL	20925738E+08	I-O, VELOCITY	223146314620
DEG/SEC//RAD/MIN	DECIMAL	32174000E+02	FT/SEC//E.R./MIN.	223146314620
RELATIVE MASS(SUN)	DECIMAL	10471976E+01	L/PERM	314631463140
(VENUS)	DECIMAL	33295130E+06	CM/PERM	614643434660
(JUPITER)	DECIMAL	81497900E+00	MARKET	203232233700
	DECIMAL	31788700E+03	(SATURN)	30446722720

(14)

CAME FROM SEGMENT 2 ARE IN SEGMENT 12 FUNCTION IS 3

OLD FUNCTION IS 3 NEW FUNCTION IS 3

12.18.49 BEGIN EXECUTION

CAME FROM SEGMENT 62 ARE IN SEGMENT 1 FUNCTION IS 3

OLD FUNCTION IS 3 NEW FUNCTION IS 3

12.18.52 BEGIN EXECUTION

CAME FROM SEGMENT 1 ARE IN SEGMENT 12 FUNCTION IS 3

CAME FROM SEGMENT 12 ARE IN SEGMENT 1 FUNCTION IS 3

OLD FUNCTION IS 3 NEW FUNCTION IS 3

CAME FROM SEGMENT 1 ARE IN SEGMENT 12 FUNCTION IS 3

OLD FUNCTION IS 3 NEW FUNCTION IS 3

Figure 18 (cont.)

7/ 8/67		15 HRS. 35 MIN.		- .00000 SEC.		(15)	
ME,MM,ST,DT	X,R	XDOT,V	LAT, LONG, H, SBV	ALPHA, DELTA, BETA, A	REV, NPD, NPCK, NREG		
35.00000	7.78647439E+07	-22.155572E+05	48.44481	120.83651095	1.26426		
935.00000	1.13174136E+08	1.1095956E+05	221.18493	48.25372594	.00000		
56100.00000	1.7192791E+08	1.5414935E+05	354.38493	89.57732323	.00000		
2.00000	2.3043252E+08	2473781E+05	48.42694	95.84605663	.00000		

ME-NN-57-01	7/ 8/67	15 HRS.	40 MIN.	↑	- .00000 SEC.	LAT, LONG, H, S, SV	ALPHA, DELTA, BETA, A	REV, NPD, NPCK, NREG
XGDI, V								
-1395619A+E+08					-1837376C+05	43.434303	146.43077687	1.31540
-92882160E+07					-14783492E+05	345.32577	43.35092053	.00000
-15857608E+08					-72765052E+04	363.35710	89.55149561	.00000
-23100393E+08					-26279845E+05	43.52467	114.38479712	.00000

MEAN, ST, DT	7/ 8/67	15 HRS.	45 MIN.	-00000 SEC.	LAT, LONG, H, SOV	ALPHA, DELTA, BETA, A	REV, NPD, IN, PK, N, REG
45.00000		X.R.	X007,V	-12753361E+05	34.04550	166.59726815	1.36628
945.08000				-17147176E+05	4.43884	33.86722360	.00000
56700.00000				-12904892E+08	370.87110	89.57441311	.00000
2.00000				23157333E+08	34.02811	127.11199948	.00000

ME-MR,SI,DI	7/ 0/67	15 HRS.	50 MIN.	-00000 SEC.	LAT,LONG,W,SBV	ALPHA,DELTA,BETA,A	REV,NPD,NPDK,NREG
			X,R	XDOT,V			
00.00000			-2152252E+08	-5879784E+04	22.00012	182.19500890	1.41695
950.00000			-.8527309E+06	-1776852E+05	18.78406	21.86679475	.00000
57000.00000			.86438611E+07	-1.15927250E+05	377.23886	89.64450786	.00000
20.00000			-23208111E+08	-24575813E+05	21.98690	134.49388396	.00000

	7/ 8/67	15 MRS.	55 MIN.	-0.0000 SEC.	LAT, LONG, N, S, W	ALPHA, DELTA, BETA, A	REV, NPD, NPKC, NREG
MR. MN. ST. OF		X-R		KDUT, V			
55.00000		- .22176610E+08		- .15507212E+04	8.74437	195.19936864	1.46742
955.00000		- .60249895E+07		- .16604303E+05	30.53409	8.68673381	.00000
57300.00000		- .35110626E+07		- .18000179E+05	382.32037	83.75379172	.00600
2.000000		- .23247153E+08		- .245380013E+05	8.73857	137.96525192	.00000

ME, MN, ST, DT	77 8/67	15 HRS.	58 MIN.	12.34578 SEC.	XDOT, V	LAT, LONG, HA, SBV	ALPHA, DELTA, BETA, A	REV, NPD, NPCK, NREG
20576	-	21422141E+08	-	62654795E+04	-	00000	202.95255504	1.5C000
20576	958.	20576	-	90722318E+07	-	14971745E+05	-	00000
20576	5742.	34578	-	12134505E+01	-	18380968E+05	37.48365	00000
20000	2.	00000	-	24520795E+05	-	384.82785	89.83857563	00000
20000	2.	00000	-	23261996E+08	-	00000	138.55663441	00000

ME,MM,ST,DT	7/ 8/67	16 HRS.	0 MIN.	X-R.	-0.0000 SEC.	XDOT,V	LAT, LONG, H, SBV	ALPHA, DELTA, BETA, A	REV, NPD, NPCK, NREG
40-00000				-20410321E+08		-879983933E+04	-4.90010	207.26480397	1.51805
960-00000				-10621752E+08		-13784272E+05	41.34611	-8.66745637	0.00000
57600-00000				-19745058E+07		-18261616E+05	385.94442	89.88918664	0.0000
9-00000				-27202735E+08		-245118738E+05	-4.89679	139.37283634	0.0000

	CAME FROM SEGMENT	31	ARE IN SEGMENT	13	FUNCTION IS	0
OLD FUNCTION IS	0	NEW FUNCTION IS	0	FUNCTION IS	0	
CAME FROM SEGMENT	13	ARE IN SEGMENT	62	FUNCTION IS	0	
OLD FUNCTION IS	3	NEW FUNCTION IS	0	FUNCTION IS	0	
CAME FROM SEGMENT	62	ARE IN SEGMENT	63	FUNCTION IS	0	

Figure 19. Ephemeris Output (Last 25 minutes of output)

Figure 20. Observation Generation Output Listing of Input

TRACE-0 STANDARD INPUT SECTION CONSTANTS													BASIC INPUT CARD	
11	1	12	2	13	0								1	2
1	1	1	1	11	1.00002518								BASIC INPUT CARD	3
23	.1	-9.26	1	30	1								BASIC INPUT CARD	4
31	.015625	32	64	33	1								BASIC INPUT CARD	5
134	4	135	1	37	.001								BASIC INPUT CARD	6
38	0.	40	2820.1763	141	1								BASIC INPUT CARD	7
GC													BASIC INPUT CARD	8
1	.437526906	2	2	.5530370	-2.6	.5							BASIC INPUT CARD	9
5	.5	8	.43752695	-2									BASIC INPUT CARD	10
9	1.	10	10										BASIC INPUT CARD	11
13	3200.0399	14	57.257795	15	20925738								BASIC INPUT CARD	12
16	332951.3	17	.0122999	18	.014979								BASIC INPUT CARD	13
19	.107821	20	317.887	21	95.129								BASIC INPUT CARD	14
22	23436.865	23	3443.93361	24	20925738								BASIC INPUT CARD	15
25	348762.3	26	32.174	30	348762.3								BASIC INPUT CARD	16
31	1.5	32	1.0471976	33	3.14159265								BASIC INPUT CARD	17
34	298.3	35	300000.	36	82505.922								BASIC INPUT CARD	18
ITMATA													BASIC INPUT CARD	19
DRAG .01	12	1	3	6.83									BASIC INPUT CARD	20
1	-18.884												BASIC INPUT CARD	21
RRREFCL													BASIC INPUT CARD	22
GC													BASIC INPUT CARD	23
1	.0437526906	2	.55303705	-2.15	20925738								BASIC INPUT CARD	24
24	20925741.	08J1		2	1.723	-6							BASIC INPUT CARD	25
3	1.856	-6.4	.4482	-6.5	.1643	-6							BASIC INPUT CARD	26
6	.7278	-6.7	.1536	-6.8	.05719	-6							BASIC INPUT CARD	27
9	.004761	-6.10	.1509	-6.11	.05329	-6							BASIC INPUT CARD	28
12	.005842	-6.13	.004093	-6.14	.0008462	-6							BASIC INPUT CARD	29
15	.06611	-6.16	.03746	-6.17	.01166	-6							BASIC INPUT CARD	30
18	.002756	-6.19	.000338	-6.20	.00005153	-6							BASIC INPUT CARD	31

Figure 20. (Cont.)

OBLT	2	-13.18	3	5.31	BASIC INPUT CARD	32
4	-13.33	5	16.00	6	BASIC INPUT CARD	33
7	27.47	8	-1.10	9	BASIC INPUT CARD	34
10	-81.86	11	-2.60	12	BASIC INPUT CARD	35
13	58.25	14	-15.32	15	BASIC INPUT CARD	36
16	115.15	17	-1.75	18	BASIC INPUT CARD	37
19	-17.75	20	-14.34	DBJZ	BASIC INPUT CARD	38
2	1082.76	-6.3	-2.693	-6.4	BASIC INPUT CARD	39
5	-0.006	-8.8	.39	-6.7	BASIC INPUT CARD	40
8	0.	9	.210	-6.1108	BASIC INPUT CARD	41
12	6	13	9	14	BASIC INPUT CARD	42
15	4	16	17	18	BASIC INPUT CARD	43
18	21	22	23	24	BASIC INPUT CARD	44
21	25	26	27	28	BASIC INPUT CARD	45
24	29	30	31	32	BASIC INPUT CARD	46
27	33	34	35	36	BASIC INPUT CARD	47
30	37	38	39	40	BASIC INPUT CARD	48
33	41	42	43	44	BASIC INPUT CARD	49
36	45	46	47	48	BASIC INPUT CARD	50
39	49	50	51	52	BASIC INPUT CARD	51
42	53	54	55	56	BASIC INPUT CARD	52
45	57	58	59	60	BASIC INPUT CARD	53
48	61	62	63	64	BASIC INPUT CARD	54
51	65	66	67	68	BASIC INPUT CARD	55
54	69	70	71	72	BASIC INPUT CARD	56
57	73	74	75	76	BASIC INPUT CARD	57
60	77	78	79	80	BASIC INPUT CARD	58
63	81	82	83	84	BASIC INPUT CARD	59
66	85	86	87	88	BASIC INPUT CARD	60
69	89	90	91	92	BASIC INPUT CARD	61
72	93	94	95	96	BASIC INPUT CARD	62
75	97	98	99	100	BASIC INPUT CARD	63
78	101	102	103	104	BASIC INPUT CARD	64
81	105	106	107	108	BASIC INPUT CARD	65
84	109	110	111	112	BASIC INPUT CARD	66
87	113	114	115	116	BASIC INPUT CARD	67
90	117	118	119	120	BASIC INPUT CARD	68
93	121	122	123	124	BASIC INPUT CARD	69
96	125	126	127	128	BASIC INPUT CARD	70
99	129	130	131	132	BASIC INPUT CARD	71
102	133	134	135	136	BASIC INPUT CARD	72
105	137	138	139	140	BASIC INPUT CARD	73
108	141	142	143	144	BASIC INPUT CARD	74
111	145	146	147	148	BASIC INPUT CARD	75
114	149	150	151	152	BASIC INPUT CARD	76
117	153	154	155	156	BASIC INPUT CARD	77
120	157	158	159	160	BASIC INPUT CARD	78
123	161	162	163	164	BASIC INPUT CARD	79
126	165	166	167	168	BASIC INPUT CARD	80
129	169	170	171	172	BASIC INPUT CARD	81
132	173	174	175	176	BASIC INPUT CARD	82
135	177	178	179	180	BASIC INPUT CARD	83
138	181	182	183	184	BASIC INPUT CARD	84
141	185	186	187	188	BASIC INPUT CARD	85
144	189	190	191	192	BASIC INPUT CARD	86
147	193	194	195	196	BASIC INPUT CARD	87
150	197	198	199	200	BASIC INPUT CARD	88
153	201	202	203	204	BASIC INPUT CARD	89
156	205	206	207	208	BASIC INPUT CARD	90
159	209	210	211	212	BASIC INPUT CARD	91
162	213	214	215	216	BASIC INPUT CARD	92
165	217	218	219	220	BASIC INPUT CARD	93
168	221	222	223	224	BASIC INPUT CARD	94
171	225	226	227	228	BASIC INPUT CARD	95
174	229	230	231	232	BASIC INPUT CARD	96
177	233	234	235	236	BASIC INPUT CARD	97
180	237	238	239	240	BASIC INPUT CARD	98
183	241	242	243	244	BASIC INPUT CARD	99
186	245	246	247	248	BASIC INPUT CARD	100
189	249	250	251	252	BASIC INPUT CARD	101
192	253	254	255	256	BASIC INPUT CARD	102
195	257	258	259	260	BASIC INPUT CARD	103
198	261	262	263	264	BASIC INPUT CARD	104
201	265	266	267	268	BASIC INPUT CARD	105
204	269	270	271	272	BASIC INPUT CARD	106
207	273	274	275	276	BASIC INPUT CARD	107
210	277	278	279	280	BASIC INPUT CARD	108
213	281	282	283	284	BASIC INPUT CARD	109
216	285	286	287	288	BASIC INPUT CARD	110
219	289	290	291	292	BASIC INPUT CARD	111
222	293	294	295	296	BASIC INPUT CARD	112
225	297	298	299	300	BASIC INPUT CARD	113
228	301	302	303	304	BASIC INPUT CARD	114
231	305	306	307	308	BASIC INPUT CARD	115
234	309	310	311	312	BASIC INPUT CARD	116
237	313	314	315	316	BASIC INPUT CARD	117
240	317	318	319	320	BASIC INPUT CARD	118
243	321	322	323	324	BASIC INPUT CARD	119
246	325	326	327	328	BASIC INPUT CARD	120
249	329	330	331	332	BASIC INPUT CARD	121
252	333	334	335	336	BASIC INPUT CARD	122
255	337	338	339	340	BASIC INPUT CARD	123
258	341	342	343	344	BASIC INPUT CARD	124
261	345	346	347	348	BASIC INPUT CARD	125
264	349	350	351	352	BASIC INPUT CARD	126
267	353	354	355	356	BASIC INPUT CARD	127
270	357	358	359	360	BASIC INPUT CARD	128
273	361	362	363	364	BASIC INPUT CARD	129
276	365	366	367	368	BASIC INPUT CARD	130
279	369	370	371	372	BASIC INPUT CARD	131
282	373	374	375	376	BASIC INPUT CARD	132
285	377	378	379	380	BASIC INPUT CARD	133
288	381	382	383	384	BASIC INPUT CARD	134
291	385	386	387	388	BASIC INPUT CARD	135
294	389	390	391	392	BASIC INPUT CARD	136
297	393	394	395	396	BASIC INPUT CARD	137
300	397	398	399	400	BASIC INPUT CARD	138
303	401	402	403	404	BASIC INPUT CARD	139
306	405	406	407	408	BASIC INPUT CARD	140
309	409	410	411	412	BASIC INPUT CARD	141
312	413	414	415	416	BASIC INPUT CARD	142
315	417	418	419	420	BASIC INPUT CARD	143
318	421	422	423	424	BASIC INPUT CARD	144
321	425	426	427	428	BASIC INPUT CARD	145
324	429	430	431	432	BASIC INPUT CARD	146
327	433	434	435	436	BASIC INPUT CARD	147
330	437	438	439	440	BASIC INPUT CARD	148
333	441	442	443	444	BASIC INPUT CARD	149
336	445	446	447	448	BASIC INPUT CARD	150
339	449	450	451	452	BASIC INPUT CARD	151
342	453	454	455	456	BASIC INPUT CARD	152
345	457	458	459	460	BASIC INPUT CARD	153
348	461	462	463	464	BASIC INPUT CARD	154
351	465	466	467	468	BASIC INPUT CARD	155
354	469	470	471	472	BASIC INPUT CARD	156
357	473	474	475	476	BASIC INPUT CARD	157
360	477	478	479	480	BASIC INPUT CARD	158
363	481	482	483	484	BASIC INPUT CARD	159
366	485	486	487	488	BASIC INPUT CARD	160
369	489	490	491	492	BASIC INPUT CARD	161
372	493	494	495	496	BASIC INPUT CARD	162
375	497	498	499	500	BASIC INPUT CARD	163
378	501	502	503	504	BASIC INPUT CARD	164
381	505	506	507	508	BASIC INPUT CARD	165
384	509	510	511	512	BASIC INPUT CARD	166
387	513	514	515	516	BASIC INPUT CARD	167
390	517	518	519	520	BASIC INPUT CARD	168
393	521	522	523	524	BASIC INPUT CARD	169
396	525	526	527	528	BASIC INPUT CARD	170
399	529	530	531	532	BASIC INPUT CARD	171
402	533	534	535	536	BASIC INPUT CARD	172
405	537	538	539	540	BASIC INPUT CARD	173
408	541	542	543	544	BASIC INPUT CARD	174
411	545	546	547	548	BASIC INPUT CARD	175
414	549	550	551	552	BASIC INPUT CARD	176
417	553	554	555	556	BASIC INPUT CARD	177
420	557	558	559	560	BASIC INPUT CARD	178
423	561	562	563	564	BASIC INPUT CARD	179
426	565	566	567	568	BASIC INPUT CARD	180
429	569	570	571	572	BASIC INPUT CARD	181
432	573	574	575	576	BASIC INPUT CARD	182
435	577	578	579	580	BASIC INPUT CARD	183
438	581	582	583	584	BASIC INPUT CARD	184
441	585	586	587	588	BASIC INPUT CARD	185
444	589	590	591	592	BASIC INPUT CARD	186
447	593	594	595	596	BASIC INPUT CARD	187
450	597	598	599	600	BASIC INPUT CARD	188
453	601	602	603	604	BASIC INPUT CARD	189
456	605	606	607	608	BASIC INPUT CARD	190
459	609	610	611	612	BASIC INPUT CARD	191
462	613	614	615	616	BASIC INPUT CARD	192
465	617	618	619	620	BASIC INPUT CARD	193
468	621	622	623	624	BASIC INPUT CARD	194
471	625	626	627	628	BASIC INPUT CARD	195
474	629	630	631	632	BASIC INPUT CARD	196
477	633	634	635	636	BASIC INPUT CARD	197
480	637	638	639	640	BASIC INPUT CARD	198
483	641	642	643	644	BASIC INPUT CARD	199
486	645	646	647	648	BASIC INPUT CARD	200
489	649	650	651	652	BASIC INPUT CARD	201
492	653	654	655	656	BASIC INPUT CARD	202
495	657	658	659	660	BASIC INPUT CARD	203
498	661	662	663	664	BASIC INPUT CARD	204
501	665	666	667	668	BASIC INPUT CARD	205
504	669	670	671	672	BASIC INPUT CARD	206
507	673	674	675	676	BASIC INPUT CARD	207
510	677	678	679	680	BASIC INPUT CARD	208
513	681	682	683	684	BASIC INPUT CARD	209
516	685	686	687	688	BASIC INPUT CARD	210
519	689	690	691	692	BASIC INPUT CARD	211
522	693	694	695	696	BASIC INPUT CARD	212
525	697	698	699	700	BASIC INPUT CARD	213
528	701	702	703	704	BASIC INPUT CARD	214
531	705	706	707	708	BASIC INPUT CARD	215
534	709	710	711	712	BASIC INPUT CARD	216
537	713	714	715	716	BASIC INPUT CARD	217
540	717	718	719	720	BASIC INPUT CARD	218
543	721	722	723	724	BASIC INPUT CARD	219
546	725	726	727	728	BASIC INPUT CARD	220
549	729	730	731	732	BASIC INPUT CARD	221
552	733	734	735	736	BASIC INPUT CARD	222
555	737	738	739	740	BASIC INPUT CARD	223
558	741	742	743	744	BASIC INPUT CARD	224
561	745	746	747	748	BASIC INPUT CARD	225
564	749	750	751	752	BASIC INPUT CARD	226
567	753	754	755	756	BASIC INPUT CARD	227
570	757	758	759	760	BASIC INPUT CARD	228
573	761	762	763	764	BASIC INPUT CARD	229
576	765	766	767	768	BASIC INPUT CARD	230
579	769	770	771	772	BASIC INPUT CARD	231
582	773	774	775	776	BASIC INPUT CARD	232
585	777	778	779	780	BASIC INPUT CARD	

[illegible]

YEAR	MONTH	DAY	TZONE	HOUR	MIN	SEC
1965.	2.	23.	.	.	.000	.000

OLD FUNCTION IS	0	NEW FUNCTION IS	4
CAME FROM SEGMENT	63	ARE IN SEGMENT	62
OLD FUNCTION IS	0	NEW FUNCTION IS	4
		FUNCTION IS	4

14.36.52	BEGIN EXECUTION	62	ARE IN SEGMENT	2	FUNCTION IS	4
	CAME FROM SEGMENT					

Figure 22. Initial Information

HRAFA05.199		BASIC INPUT CARD 1	
D01.0188 RH1AS 03.011000.1		BASIC INPUT CARD 2	
END		BASIC INPUT CARD 3	
(1)			
SIGMA TABLE			
1	.1000000E+03	2	.1000000E-00 3
7	.5000000E-01	8	.5000000E-01 13
		4	.1000000E-00 4
		5	.5000000E-01 5
		6	.5000000E-01 6
		15	.1000000E+04 15
		19	.1000000E-00 19
			(2)
INITIAL CONDITIONS			
X	-.1005600E+07	ALPHA	-.9267667E+02
Y	.21509820E+08	DELTA	.0000000E 00
Z	.00000000E 00	BETA	.90000000E+02
XDOT	-.1079365E+05	AZ	.25000000E+02
YDOT	-.5046108E+03	R	.2153333E+08
ZDOT	.2317235E+05	V	.2556786E+05
		A	.2153333E+08
		E	.3586534E-09
		I	.65000000E+02
		C	.9267667E+02
		U	.9000551E+02
		T	-.6614570E+02
ATMOSPHERE - LOCKHEED			
CDA/M = .1000000E-01		W/CDA = .10000000E+03	
D1 = .68300000E+01		D2 = -.15684000E+02	
EARTH MODEL			
GM	.55304505E-02	J2	.10827600E-02
J6	.39000000E-06	J7	-.63300000E-06
J21	.00000000E 00	J8	.00000000E 00
J22	.17230000E-05	J9	.21000000E-06
J31	.18560000E-05	J10	.00000000E 00
J32	.44820000E-06	J11	.26000000E+01
J33	.16430000E-06	J12	-.34500000E+01
J41	.27280000E-06	J13	.58250000E+02
J42	.15360000E-06	J14	.15320000E+02
J43	.57190000E-07	J15	.15721000E+03
J44	.47810000E-08	J16	.11315000E+03
J51	.15090000E-06	J17	.37460000E-07
		J18	.11660000E-07
		J19	.22560000E-08
		J20	.33280000E-09
		J21	.51530000E-10
		J22	.14340000E+02
THE FOLLOWING BODIES ARE USED FOR PLANETARY PERTURBATIONS			
NONE			
FORMULATION			
COWELL (EQU. OF MOTION)			
DIFFERENTIAL EQUATION SUBROUTINE			
STEP SIZE - INITIAL		E BAR = .1000E-09	
DO NOT RECOMPUTE PERTURBATIONS FOR CORRECTOR		A = 1.000	
EQUATIONS OF MOTION		RATIO OF COWELL STEP TO RUNGE KUTTA 4	
USE N1 = 9 N2 = 6		MAXIMUM = .6400E+02	
CONSTANTS			
DECIMAL	OCIAL	DECIMAL	OCIAL
OMEGA E	.43752695E-02	OMEGA E	.62001712354C
ALPHA G	.26647105E+01	ALPHA G	.55304505E-02

FT/KM	.3200839E+04	34035333740	EARTH RADIUS - FT	.20925741E+08	455000000000
E.R./A.U.	.23454865E+05	565605075320	N.M./E.R.	.34439336E+04	740032155600
I-O, DISTANCE	.20925741E+08	455000000000	I-O, VELOCITY	.34876230E+06	223146314620
G	.3217600E+02	132071260100	FT/SEC/E.R./MIN.	.34876230E+06	223146314620
DEG/SEC/RAD/MIN	.19471976E+01	444250714340	1/EPS.	.2983000E+03	314631463140
RELATIVE MASS(SUN)	.33292130E+06	723146314620	(MOON)	.1229990E+01	412076346600
(VENUS)	.0149790E+00	355337552020	(MARS)	.10782100E+00	20323223700
(JUPITER)	.3178970E+03	422335136140	(SATURN)	.95129000E+02	3044672720

CAME FROM SEGMENT 2 ARE IN SEGMENT 62 FUNCTION IS 4
 OLD FUNCTION IS 4 NEW FUNCTION IS 4

14.36.56 BEGIN EXECUTION

CAME FROM SEGMENT 62 ARE IN SEGMENT 1 FUNCTION IS 4
 OLD FUNCTION IS 4 NEW FUNCTION IS 4

14.36.58 BEGIN EXECUTION

CAME FROM SEGMENT 1 ARE IN SEGMENT 12 FUNCTION IS 4

Figure 22 (cont.)

Figure 23. Data Specifications

STATIONS		SIG REF		LATITUDE		LONGITUDE		HEIGHT	
AA	.	.	.	75.00000000	.	300.00000000	.	1000.0000	.
BB	.	.	.	45.00000000	.	240.00000000	.	100.0000	.
CC00000000	.	315.00000000	.	500.0000	.
DD00000000	.	15.00000000	.	200.0000	.
EE	.	.	.	-15.00000000	.	135.00000000	.	100.0000	.
FF	.	.	.	-65.00000000	.	75.00000000	.	5000.0000	.

(3)

DATA											
INTERVAL		MIN.EL	MAX.EL	MAX.RANGE	MDT	START		STOP			
SEC.	DEG.	DEG.	N.M	N.M	MIN.	DA	HR	DA	HR	MN	MN
AA 15.0000	.00	.00	.00	.	.0	.	.70.	.	.24.	.	.
BB 15.0000	.00	.00	.	.	.0	.	.70.	.	.24.	.	.
CC 15.0000	.00	.00	.	.	.0	.	.70.	.	.24.	.	.
DD 15.0000	.00	.00	.	.	.0	.	.70.	.	.24.	.	.
EE 15.0000	.00	.00	.	.	.0	.	.70.	.	.24.	.	.
FF 15.0000	.00	.00	.	.	.0	.	.70.	.	.24.	.	.

(4)

PARAMETERS TO BE CORRECTED

BB
BIAS (5)

DATA TYPES											
S	RANGE	AZMTH	ELEV.	R.DOT	P.DOT	Q.DOT	P	Q	AZ.DT	E.DOT	R.DOT
T	A	SUR.R	HIGHT	DOPLR	LOOK	VARI.	KAPPA	ASPCT	ATTEN	X,Y,Z	T-R,C
T										G-R,D	HR.ANG.
										U,V	

AA	X	X	X	X	X						
BB	X	X	X	X	X						
CC	X	X	X	X	X						
DD	X	X	X	X	X						
EE	X	X	X	X	X						
FF	X	X	X	X	X						

(6)

CAME FROM SEGMENT 12 ARE IN SEGMENT 1 FUNCTION IS 4											
OLD FUNCTION IS 4 NEW FUNCTION IS 4											
CAME FROM SEGMENT 1 ARE IN SEGMENT 62 FUNCTION IS 4											
OLD FUNCTION IS 4 NEW FUNCTION IS 4											

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Figure 24 (cont.)

FEBRUARY 23, 1965

ST	HR	MINS	T-ST	RANGE QM-Y YARDS	AZIMUTH DEGREES	ELEVATION DEGREES	RATE FT/SEC	CM-Y YARDS	X DEGREES	Y DEGREES	Z TOP RT, ASC DEGREES
				TOP DECLIN DEGREES	GEO RT, ASC DEGREES	SEC DECLIN DEGREES	TOP HR, ANG DEGREES	U DEGREES	V DEGREES	Y DEGREES	
BB	4.	33.25	273.25	824.583	146.101	947	-14120.608	-1090.303	-2761.350	1931.005	142.384
BB	4.	33.50	273.50	-36.695	109.545	32.937	318.752	36.990	2.207	1976.559	146.073
BB	4.	33.75	273.75	791.225	144.488	1.382	-12858.371	-1052.816	-2744.016	1976.559	146.073
BB	4.	34.00	274.00	-34.273	110.342	33.831	315.185	38.011	52.849	2020.881	149.823
BB	4.	34.25	274.25	761.258	140.606	1.847	-11430.015	-1014.499	-2725.958	2020.881	149.823
BB	4.	34.50	274.50	-31.768	110.856	34.761	311.506	39.032	53.463	2064.999	153.686
BB	4.	34.75	274.75	734.923	136.292	2.426	-9830.536	-876.125	-2706.477	2064.999	153.686
BB	4.	35.00	275.00	-29.094	111.499	35.634	307.717	40.053	54.052	2108.533	157.456
BB	4.	35.25	275.25	712.835	131.735	2.580	-8061.687	-937.243	-2686.516	2108.533	157.456
BB	4.	35.50	275.50	-26.147	112.253	36.483	303.912	41.074	54.617	2151.478	161.617
BB	4.	35.75	275.75	695.282	127.075	3.069	-6136.014	-897.994	-2666.067	2151.478	161.617
BB	4.	36.00	276.00	-22.968	112.830	37.453	299.906	42.095	55.157	2193.127	165.635
BB	4.	36.25	276.25	682.671	121.944	3.273	-4078.574	-858.816	-2644.261	2193.127	165.635
BB	4.	36.50	276.50	-19.566	113.480	36.209	295.850	43.116	55.675	2234.590	169.611
BB	4.	36.75	276.75	675.241	116.710	3.584	-1927.175	-818.891	-2621.992	2234.590	169.611
BB	4.	37.00	277.00	-16.110	114.217	39.090	291.897	44.137	56.172	2275.219	173.764
BB	4.	37.25	277.25	673.200	111.575	3.539	271.158	-778.823	-2599.453	2275.219	173.764
BB	4.	37.50	277.50	-12.624	114.980	40.061	287.876	45.158	56.648	2315.230	177.842
BB	4.	37.75	277.75	676.570	106.379	3.310	2462.983	-738.242	-2575.600	2315.230	177.842
BB	4.	38.00	278.00	-9.039	115.767	40.858	283.914	46.179	57.103	2354.177	181.731
BB	4.	38.25	278.25	685.318	101.208	3.412	4596.676	-697.821	-2551.261	2354.177	181.731
BB	4.	38.50	278.50	-5.685	116.557	41.678	280.135	47.200	57.540	2392.713	185.522
BB	4.	38.75	278.75	699.155	96.345	2.951	6626.616	-657.093	-2526.583	2392.713	185.522
BB	4.	39.00	279.00	-2.469	117.317	42.491	276.378	48.221	57.959	2430.301	189.163
BB	4.	39.25	279.25	717.894	91.502	2.695	8518.012	-615.847	-2500.517	2430.301	189.163
BB	4.	39.50	279.50	-5.25	118.176	43.330	272.712	49.242	58.360	2467.506	192.671
BB	4.	39.75	279.75	741.082	87.009	2.224	10248.754	-574.153	-2473.836	2467.506	192.671
BB	4.	40.00	280.00	3.582	118.931	44.102	269.398	50.263	58.744	2503.773	196.169
BB	4.	40.25	280.25	768.327	82.804	1.852	11808.934	-532.641	-2446.770	2503.773	196.169
BB	4.	40.50	280.50	-6.008	119.796	44.983	263.928	51.285	59.111	2538.768	199.309
BB	4.	40.75	280.75	799.223	79.017	1.125	13198.797	-490.672	-2418.845	2538.768	199.309
BB	4.	41.00	281.00	-8.378	120.652	45.792	262.762	52.306	59.464	2573.149	202.320
BB	4.	41.25	281.25	833.377	75.579	1.038	14425.412	-448.228	-2390.327	2573.149	202.320
BB	4.	41.50	281.50	-10.429	121.607	46.588	259.860	53.327	59.801	2618.493	205.880
BB	4.	41.75	281.75	868.339	62.231	1.304	23616.336	-1939.243	-2134.200	2618.493	205.880
BB	4.	42.00	282.00	-26.924	121.217	35.496	58.250	39.835	53.932	2659.512	209.049
BB	4.	42.25	282.25	750.146	230.414	1.911	-23518.703	-1896.105	-2130.351	2659.512	209.049
BB	4.	42.50	282.50	-25.454	111.879	36.375	58.453	40.856	54.501	2142.083	212.613
BB	4.	42.75	282.75	692.273	231.523	3.312	-23387.981	-1852.034	-2126.213	2142.083	212.613
BB	4.	43.00	283.00	-23.949	112.497	37.206	58.698	41.877	55.047	2184.493	216.550
BB	4.	43.25	283.25	634.744	233.061	4.435	-23212.145	-1807.965	-2122.050	2184.493	216.550
BB	4.	43.50	283.50	-22.047	113.209	38.127	59.115	42.898	55.570	2228.770	220.700

Figure 25. Orbit Determination Output Listing of Input

TRACE-D STANDARD INTEGRATION CONSTANTS										BASIC INPUT CARD	
LINE	1	2	3	4	5	6	7	8	9	10	11
11	1	12	2	13	0					BASIC INPUT CARD	2
4	1	5	1	11	1.00002516					BASIC INPUT CARD	3
23	.1	-9								BASIC INPUT CARD	4
26	1									BASIC INPUT CARD	5
30	1	31	.015625	32	64	33	1	-7		BASIC INPUT CARD	6
134	4	135	1	37	.0001	38	0.			BASIC INPUT CARD	7
40	2820.18012	141	1							BASIC INPUT CARD	8
GC TRACE-D STANDARD PHYSICAL CONSTANTS 10/ 1/65										BASIC INPUT CARD	9
1	.437526904-2	2	.58304263 -2	6	.5					BASIC INPUT CARD	10
8	.437526904-2	9	1.	10	10					BASIC INPUT CARD	11
13	3280.8399	14	57.2957795	15	20925738					BASIC INPUT CARD	12
16	332951.3	17	.01229853	18	.814979					BASIC INPUT CARD	13
19	.107821	20	317.887	21	95.129					BASIC INPUT CARD	14
22	23454.865	23	3443.93355	24	20925738					BASIC INPUT CARD	15
25	348762.3	26	32.174	30	348762.3					BASIC INPUT CARD	16
31	1.5	32	1.0471976	33	3.14159265					BASIC INPUT CARD	17
34	298.3	35	300000.	36	82505.922					BASIC INPUT CARD	18
NUMB 42 3443.9336										BASIC INPUT CARD	19
OITIN 12										BASIC INPUT CARD	20
DPRCDE X X										BASIC INPUT CARD	21
TICTYPE2										BASIC INPUT CARD	22
1C	23.11454									BASIC INPUT CARD	23
2	26.51516									BASIC INPUT CARD	24
3	89.88977									BASIC INPUT CARD	25
4	45.73312									BASIC INPUT CARD	26
5	24780836.7									BASIC INPUT CARD	27
6	23785.259									BASIC INPUT CARD	28
IMAX111										BASIC INPUT CARD	29
IYEAR 1967										BASIC INPUT CARD	30
IMNTH 7										BASIC INPUT CARD	31
IDAY 8										BASIC INPUT CARD	32

TZNE O

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Figure 25 (cont.)

5	22.96	BASIC INPUT CARD	64
6	.06036	BASIC INPUT CARD	65
IPIAPE4			
11	SIG 101	BASIC INPUT CARD	67
12	119	BASIC INPUT CARD	68
13	201	BASIC INPUT CARD	69
14	219	BASIC INPUT CARD	70
15	301	BASIC INPUT CARD	71
16	319	BASIC INPUT CARD	72
DCPRAM2XXXXXX			
DDPRAMXXXX			
BHD\$ 1.5			
2	1.5	BASIC INPUT CARD	76
3	.3	BASIC INPUT CARD	77
4	.75	BASIC INPUT CARD	78
5	4920.	BASIC INPUT CARD	79
6	492.	BASIC INPUT CARD	80
7	.15	BASIC INPUT CARD	81
8	.1	BASIC INPUT CARD	82
9	.1	BASIC INPUT CARD	83
10	.1	BASIC INPUT CARD	84
END			
BASIC INPUT CARD 85			

Figure 26 (cont.)

7	8	14	54	13.0356	MH	70	--16183004E+05	.00000000E 00	.00000000E 00
7	8	14	54	16.7956	MH	70	--16115744E+05	.00000000E 00	.00000000E 00
7	8	14	54	20.5955	MH	70	--16046088E+05	.00000000E 00	.00000000E 00
7	8	14	54	23.4548	MH	10	--78534983E+07	.00000000E 00	.00000000E 00
7	8	14	54	26.3555	MH	70	--15875297E+05	.00000000E 00	.00000000E 00
7	8	14	54	29.1154	MH	70	--15902687E+05	.00000000E 00	.00000000E 00
7	8	14	54	31.8753	MH	70	--15828202E+05	.00000000E 00	.00000000E 00
7	8	14	54	34.1106	MH	10	--76731863E+07	.00000000E 00	.00000000E 00
7	8	14	54	35.6353	MH	70	--15751775E+05	.00000000E 00	.00000000E 00
7	8	14	54	37.3952	MH	70	--15673354E+05	.00000000E 00	.00000000E 00
7	8	14	54	40.1552	MH	70	--15592932E+05	.00000000E 00	.00000000E 00
7	8	14	54	42.5784	MH	10	--74935796E+07	.00000000E 00	.00000000E 00
7	8	14	54	46.9151	MH	70	--15510398E+05	.00000000E 00	.00000000E 00
7	8	14	54	50.6750	MH	70	--15425733E+05	.00000000E 00	.00000000E 00
7	8	14	54	54.4350	MH	70	--15338886E+05	.00000000E 00	.00000000E 00
7	8	14	54	56.8593	MH	10	--73197144E+07	.00000000E 00	.00000000E 00
7	8	14	54	58.1949	MH	70	--15350051E+05	.00000000E 00	.00000000E 00
7	8	14	55	1.9549	MH	70	--15158382E+05	.00000000E 00	.00000000E 00
7	8	14	55	5.7148	MH	70	--15064618E+05	.00000000E 00	.00000000E 00
7	8	14	55	8.1361	MH	10	--71989035E+07	.00000000E 00	.00000000E 00
7	8	14	55	9.4747	MH	70	--14968426E+05	.00000000E 00	.00000000E 00
7	8	14	55	13.2347	MH	70	--14869750E+05	.00000000E 00	.00000000E 00
7	8	14	55	16.9946	MH	70	--14768548E+05	.00000000E 00	.00000000E 00
7	8	14	55	19.4179	MH	10	--69813415E+07	.00000000E 00	.00000000E 00
7	8	14	55	20.7546	MH	70	--14664727E+05	.00000000E 00	.00000000E 00
7	8	14	55	24.5145	MH	70	--14558237E+05	.00000000E 00	.00000000E 00
7	8	14	55	28.2745	MH	70	--14449018E+05	.00000000E 00	.00000000E 00
7	8	14	55	30.6858	MH	10	--68146050E+07	.00000000E 00	.00000000E 00
7	8	14	55	32.0344	MH	70	--14336992E+05	.00000000E 00	.00000000E 00
7	8	14	55	35.7943	MH	70	--14222113E+05	.00000000E 00	.00000000E 00
7	8	14	55	39.5543	MH	70	--14104283E+05	.00000000E 00	.00000000E 00
7	8	14	55	42.3536	MH	10	--66518137E+07	.00000000E 00	.00000000E 00
7	8	14	55	43.3142	MH	70	--13983450E+05	.00000000E 00	.00000000E 00
7	8	14	55	47.0742	MH	70	--13859568E+05	.00000000E 00	.00000000E 00
7	8	14	55	50.8341	MH	70	--13732534E+05	.00000000E 00	.00000000E 00
7	8	14	55	53.6334	MH	10	--64958471E+07	.00000000E 00	.00000000E 00
7	8	14	55	54.5941	MH	70	--13602290E+05	.00000000E 00	.00000000E 00
7	8	14	55	58.3540	MH	70	--13468764E+05	.00000000E 00	.00000000E 00
7	8	14	56	2.1140	MH	70	--13331885E+05	.00000000E 00	.00000000E 00
7	8	14	56	4.9133	MH	10	--63443140E+07	.00000000E 00	.00000000E 00
7	8	14	56	5.8739	MH	70	--13191593E+05	.00000000E 00	.00000000E 00
7	8	14	56	9.6339	MH	70	--13047808E+05	.00000000E 00	.00000000E 00
7	8	14	56	13.3938	MH	70	--12900445E+05	.00000000E 00	.00000000E 00
7	8	14	56	16.1931	MH	10	--61975452E+07	.00000000E 00	.00000000E 00
7	8	14	56	17.1538	MH	70	--12749447E+05	.00000000E 00	.00000000E 00
7	8	14	56	20.9137	MH	70	--12594759E+05	.00000000E 00	.00000000E 00
7	8	14	56	24.6737	MH	70	--12436287E+05	.00000000E 00	.00000000E 00
7	8	14	56	27.4730	MH	10	--60559275E+07	.00000000E 00	.00000000E 00
7	8	14	56	28.4336	MH	70	--12273939E+05	.00000000E 00	.00000000E 00
7	8	14	56	31.8176	MH	70	--12124540E+05	.00000000E 00	.00000000E 00
7	8	14	56	35.8006	MH	10	--57145904E+07	.00000000E 00	.00000000E 00
7	8	14	56	37.4793	MH	70	--10883785E+05	.00000000E 00	.00000000E 00
7	8	14	56	41.4793	MH	70	--11177132E+05	.00000000E 00	.00000000E 00
7	8	14	57	1.2393	MH	70	--10685378E+05	.00000000E 00	.00000000E 00
7	8	14	57	1.2393	BH	70	--10985441E+05	.00000000E 00	.00000000E 00
7	8	14	57	4.9992	MH	70	--10482536E+05	.00000000E 00	.00000000E 00
7	8	14	57	4.9992	BH	70	--10789370E+05	.00000000E 00	.00000000E 00
7	8	14	57	8.7592	MH	70	--10275272E+05	.00000000E 00	.00000000E 00
7	8	14	57	8.7592	BH	70	--10406459E+05	.00000000E 00	.00000000E 00
7	8	14	57	8.7592	BH	70	--10588926E+05	.00000000E 00	.00000000E 00
7	8	14	57	11.0885	MH	10	--5640412E+07	.00000000E 00	.00000000E 00
7	8	14	57	12.5191	MH	70	--10063541E+05	.00000000E 00	.00000000E 00
7	8	14	57	12.5191	BH	70	--10384037E+05	.00000000E 00	.00000000E 00
7	8	14	57	16.2791	MH	70	--98473123E+04	.00000000E 00	.00000000E 00
7	8	14	57	16.2791	BH	70	--99474444E+04	.00000000E 00	.00000000E 00

Figure 26 (cont.)

7	8	16	49	16.3007	MH	70	-1592C201E+05	.C000000E 00
7	8	16	49	19.6847	MH	70	-15844733E+05	.C000000E 00
7	8	16	49	19.6847	BD	70	-15919783E+05	.C000000E 00
7	8	16	49	23.4446	MH	70	-15758649E+05	.C000000E 00
7	8	16	49	23.4446	BD	70	-15835988E+05	.C000000E 00
7	8	16	49	27.2046	MH	70	-15670155E+05	.C000000E 00
7	8	16	49	27.2046	BD	70	-15749923E+05	.C000000E 00
7	8	16	49	27.5679	MH	70	-69524422E+07	.C000000E 00
7	8	16	49	30.9645	MH	70	-15579191E+05	.C000000E 00
7	8	16	49	30.9645	BD	70	-15661681E+05	.C000000E 00
7	8	16	49	30.9645	BD	70	-15745267E+05	.C000000E 00
7	8	16	49	34.7245	MH	70	-15485680E+05	.C000000E 00
7	8	16	49	34.7245	BD	70	-15570657E+05	.C000000E 00
7	8	16	49	34.7245	BD	70	-15655694E+05	.C000000E 00
7	8	16	49	37.9204	MH	70	-15404131E+05	.C000000E 00
7	8	16	49	37.9204	BD	70	-15577519E+05	.C000000E 00
7	8	16	49	38.8477	MH	70	-6773553E+07	.C000000E 00
7	8	16	49	42.5963	MH	70	-15281319E+05	.C000000E 00
7	8	16	49	42.5963	BD	70	-15372063E+05	.C000000E 00
7	8	16	49	42.5963	BD	70	-15459887E+05	.C000000E 00
7	8	16	49	47.0783	MH	70	-15159574E+05	.C000000E 00
7	8	16	49	47.0783	BD	70	-15254576E+05	.C000000E 00
7	8	16	49	49.4822	MH	70	-15092622E+05	.C000000E 00
7	8	16	49	49.4822	BD	70	-15188788E+05	.C000000E 00
7	8	16	49	50.1275	MH	70	-66055733E+07	.C000000E 00
7	8	16	49	53.8062	MH	70	-14969175E+05	.C000000E 00
7	8	16	49	53.8062	BD	70	-1508604E+05	.C000000E 00
7	8	16	49	57.2841	MH	70	-15160727E+05	.C000000E 00
7	8	16	49	57.2841	BD	70	-14866995E+05	.C000000E 00
7	8	16	49	57.2841	BD	70	-14969642E+05	.C000000E 00
7	8	16	49	57.2841	BD	70	-15062846E+05	.C000000E 00
7	8	16	50	.8960	MH	70	-14758099E+05	.C000000E 00
7	8	16	50	.8960	BD	70	-14863678E+05	.C000000E 00
7	8	16	50	.8960	BD	70	-14938410E+05	.C000000E 00
7	8	16	50	1.4074	MH	70	-64373838E+07	.C000000E 00
7	8	16	50	4.8040	MH	70	-14636991E+05	.C000000E 00

PARAMETERS TO BE CORRECTED (4)

ALPHA DELTA BETA A R V CDAYN CM J2 J3 J4

1 ITERATIONS (MAXIMUM), (5) 1C PARAMETERS (7)

(6) 556 OBSERVATION TIMES, 1668 OBSERVATIONS, (6) 3 STATIONS, 3336 CELLS IN COMPACTED DATA LIST (11)

4 BLOCKS (IF BCD INPUT)

OLD FUNCTION IS	1	NEW FUNCTION IS	2
CAME FROM SEGMENT	11	ARE IN SEGMENT	1
OLD FUNCTION IS	1	NEW FUNCTION IS	2
CAME FROM SEGMENT	1	ARE IN SEGMENT	62
OLD FUNCTION IS	1	NEW FUNCTION IS	2

14-09-48 BEGIN EXECUTION

CAME FROM SEGMENT 62 ARE IN SEGMENT 2 FUNCTION IS 2

BASIC INPUT CARD

BOUND	.150000E+01	.300000E-00	.750000E+00	.492000E+04	.150000E-00	.100000E-07
	.150000E+01	.300000E-00	.750000E+00	.492000E+04	.150000E-00	.100000E-07

101	2296000E+02119	6056000E=01201	2296000E+02219	6056000E=C1301	2296000E+02319	6056000E=01	(15)
101	2296000E+02119	6056000E=01201	2296000E+02219	6056000E=C1301	2296000E+02319	6056000E=01	(15)

X	=	• 20394186E+08	ALPHA=	• 2311454CE+02	A=	• 24639581E+08
Y	=	- 87049750E+07	DELTA=	• 26515160E+02	C=	• 60470640E-02
Z	=	- 11063023E+08	BETA=	• 89889770E+02	F=	• 50150382E+02
XD001	=	- 1354234E+05	AZ	• 4573313CE+02	G=	• 35850659E+03
YD001	=	• 12760866E+05	R	• 247608037E+08	U=	• 23399700E+03
ZD001	=	• 14863762E+05	V	• 23765259E+05	T=	• 83661994E+03

GM=	J2=	J3=	J4=	J5=
.5536203E-02	.1C826450E-C2	-.25460000E-05	-.16490000E-05	-.21000000E-C6
.6460000E-06	-.3330000E-06	J8=	-.5300000E-07	-.5460000E-C7
J21=	.0000000E-00	J52=	.5846000E-07	-.2419000E+02
J22=	.1566400E-05	J53=	.7219000E-07	-.5858000E+02
J31=	.1728700E-05	J54=	.1605000E-08	.3237000E+02
J32=	.3025000E-06	J55=	.1029000E-08	-.1579000E+02
J33=	.1966000E-06	J61=	.9572000E-07	.9946000E+02
J41=	.5234000E-06	J62=	.2928000E-07	-.3887000E+02
J42=	.1372000E-06	J63=	.1037000E-08	.6030000E-00
J43=	.4166000E-07	J64=	.1500000E-08	-.1954000E+02
J44=	.9378000E-08	J65=	.3810000E-09	-.2528000E+02
J51=	.12470000E-06	J66=	.16100000E-09	.1659000E+02

JING

```

DIFFERENTIAL EQUATION SUBROUTINE
GAUSS-JACKSON
A= 1.000      RATIO OF CORVALL STEP TO RUNGE KUTTA 4
E BAR= .100E-09
STEP SIZE = INITIAL= .1000E+01 - MINIMUM= .1562E-01
MAXIMUM= .6400E+02
DO NOT RECOMPUTE PERTURBATIONS FOR CORRECTOR

```

VARIATIONAL EQUATIONS USE N1 = 10 N2 = 6 FOR V MATRIX
NO T MATRIX

	DECIMAL	QCTAL	CONSTANTS	DECIMAL	QCTAL
OMEGA E	-43752690E-02	125330203250	GM	.55304703E-02	4162454532500
ALPHA G	-49787546E+01	752211125620			
BETA H	13608130E+04	163053733750	FARTH	660105	-10
DELTA I					

E-R./A.U.	.23454865E+05	565605075320	N.M./E.R.	.34439335E+04	737510377420
I-O, DISTANCE	.20925738E+08	452000000000	I-O, VELOCITY	.34876230E+06	223146314620
G	.32174050E+02	132012260100	FI/SEC./E-R./MIN.	.34876230E+06	223146314620
DEG/SEC./RAD/MIN	.10471976E+01	444250718340	1/SEPS.	.29830000E+03	314631463140
RELATIVE MASS(SUN)	.33295130E+06	723146314620	(MCON)	.12296530E-01	614043432460
VENUST	.81497900E+00	955337552020	(MARS)	.10782100E-00	293732333700
(JUPITER)	.31788700E+03	422335136140	(SATURN)	.95129000E+02	30446722720

CAME FROM SEGMENT 2 ARE IN SEGMENT 62 FUNCTION IS 2
OLD FUNCTION IS 2 NEW FUNCTION IS 2

14.09.51 BEGIN EXECUTION
CAME FROM SEGMENT 62 ARE IN SEGMENT 1 FUNCTION IS
OLD FUNCTION IS 2 NEW FUNCTION IS 2

14.09.54 BEGIN EXECUTION
CAME FROM SEGMENT 1 ARE IN SEGMENT 12 FUNCTION IS 2

Figure 27 (cont.)

COMPUTED VALUES FOR ITERATION 1 7/ 8/67 885.000 MIN. Figure 28. Computed Values

A/E, I.D.U.T	MEAN ANM= 161.33899	APGEE= 4079.67530	
.24639581E+08	TRUE ANM= 161.55913	MT = 640.21816	
.60470640E+02	ODOT= -3.60450	PERIGEE= 4036.63175	
.50150392E+02		MT = 591.17461	(16)
.35850639E+03		PERIOD(K)= 107.95173	
.23399700E+03		PERIOD(J)= 107.90175	
.83661994E+03		PERIOD(N)= 107.83470	
	CAME FROM SEGMENT 12	ARE IN SEGMENT 1	FUNCTION IS 2
	OLD FUNCTION IS 2	NEW FUNCTION IS 2	
	CAME FROM SEGMENT 1	ARE IN SEGMENT 62	FUNCTION IS 2
	OLD FUNCTION IS 2	NEW FUNCTION IS 2	

14.09.58 BEGIN EXECUTION
 14.10.02 BEGIN EXECUTION
 CAME FROM SEGMENT 62 ARE IN SEGMENT 13 FUNCTION IS 2

14.10.03 BEGIN EXECUTION
 CAME FROM SEGMENT 13 ARE IN SEGMENT 21 FUNCTION IS 2
 EC1 COORDINATES OF POSITION AND VELOCITY AT ALL NODAL CROSSINGS WITHIN THE DATA SPAN IN EARTH RADII UNITS

7/ 8/67 928.51826 MM
 -.11723811230828E+01 .33186605308784E-C1 -.44360801643162E-07 -.88733583935479E-03 -.44075741531771E-01 -.5284312552297E-C1
 7/ 8/67 982.07495 MM
 .11809726324098E+01 -.36221085592795E-01 .26694674803984E-07 .17022679758151E-02 .43732751948509E-01 .52457384667182E-C1
 CAME FROM SEGMENT 21 ARE IN SEGMENT 13 FUNCTION IS 2
 OLD FUNCTION IS 0 NEW FUNCTION IS 2
 CAME FROM SEGMENT 13 ARE IN SEGMENT 62 FUNCTION IS 2
 OLD FUNCTION IS 2 NEW FUNCTION IS 2

14.11.30 BEGIN EXECUTION
 14.11.40 BEGIN EXECUTION
 CAME FROM SEGMENT 62 ARE IN SEGMENT 15 FUNCTION IS 2

RESIDUAL	(19)	(20)
35996.7706	0000E 001(PD)	0000E 00
36001.2185	0000E 001(PD)	0000E 00
36005.9664	0000E 001(PD)	0000E 00
36009.9604	0000E 001(PD)	0000E 00
36014.4423	0000E 001(PD)	0000E 00
36018.7262	0000E 001(PD)	0000E 00
36022.5562	0000E 001(PD)	0000E 00
36026.3395	0000E 001(PD)	0000E 00
36030.2880	0000E 001(PD)	0000E 00
36034.0480	0000E 001(PD)	0000E 00
36037.9419	0000E 001(PD)	0000E 00
36041.7558	0000E 001(PD)	0000E 00
36045.5158	0000E 001(PD)	0000E 00
36049.2757	0000E 001(PD)	0000E 00
36053.0356	0000E 001(PD)	0000E 00
36056.7956	0000E 001(PD)	0000E 00
36060.5555	0000E 001(PD)	0000E 00
36064.3152	0000E 001(PD)	0000E 00
36068.0751	0000E 001(PD)	0000E 00
36071.8353	0000E 001(PD)	0000E 00
36075.5952	0000E 001(PD)	0000E 00
36079.3552	0000E 001(PD)	0000E 00
36083.1152	0000E 001(PD)	0000E 00
36086.8751	0000E 001(PD)	0000E 00
36090.6351	0000E 001(PD)	0000E 00
36094.3951	0000E 001(PD)	0000E 00
36098.1551	0000E 001(PD)	0000E 00
36101.9151	0000E 001(PD)	0000E 00
36105.6751	0000E 001(PD)	0000E 00
36109.4351	0000E 001(PD)	0000E 00
36113.1951	0000E 001(PD)	0000E 00
36116.9551	0000E 001(PD)	0000E 00
36120.7151	0000E 001(PD)	0000E 00
36124.4751	0000E 001(PD)	0000E 00
36128.2351	0000E 001(PD)	0000E 00
36131.9951	0000E 001(PD)	0000E 00
36135.7551	0000E 001(PD)	0000E 00
36139.5151	0000E 001(PD)	0000E 00
36143.2751	0000E 001(PD)	0000E 00
36147.0351	0000E 001(PD)	0000E 00
36150.7951	0000E 001(PD)	0000E 00
36154.5551	0000E 001(PD)	0000E 00
36158.3151	0000E 001(PD)	0000E 00
36162.0751	0000E 001(PD)	0000E 00
36165.8351	0000E 001(PD)	0000E 00
36169.5951	0000E 001(PD)	0000E 00
36173.3551	0000E 001(PD)	0000E 00
36177.1151	0000E 001(PD)	0000E 00
36180.8751	0000E 001(PD)	0000E 00
36184.6351	0000E 001(PD)	0000E 00
36188.3951	0000E 001(PD)	0000E 00
36192.1551	0000E 001(PD)	0000E 00
36195.9151	0000E 001(PD)	0000E 00
36199.6751	0000E 001(PD)	0000E 00
36203.4351	0000E 001(PD)	0000E 00
36207.1951	0000E 001(PD)	0000E 00
36210.9551	0000E 001(PD)	0000E 00
36214.7151	0000E 001(PD)	0000E 00
36218.4751	0000E 001(PD)	0000E 00
36222.2351	0000E 001(PD)	0000E 00
36225.9951	0000E 001(PD)	0000E 00
36229.7551	0000E 001(PD)	0000E 00
36233.5151	0000E 001(PD)	0000E 00
36237.2751	0000E 001(PD)	0000E 00
36241.0351	0000E 001(PD)	0000E 00
36244.7951	0000E 001(PD)	0000E 00
36248.5551	0000E 001(PD)	0000E 00
36252.3151	0000E 001(PD)	0000E 00
36256.0751	0000E 001(PD)	0000E 00
36259.8351	0000E 001(PD)	0000E 00
36263.5951	0000E 001(PD)	0000E 00
36267.3551	0000E 001(PD)	0000E 00
36271.1151	0000E 001(PD)	0000E 00
36274.8751	0000E 001(PD)	0000E 00
36278.6351	0000E 001(PD)	0000E 00
36282.3951	0000E 001(PD)	0000E 00
36286.1551	0000E 001(PD)	0000E 00
36289.9151	0000E 001(PD)	0000E 00
36293.6751	0000E 001(PD)	0000E 00
36297.4351	0000E 001(PD)	0000E 00
36301.1951	0000E 001(PD)	0000E 00
36304.9551	0000E 001(PD)	0000E 00
36308.7151	0000E 001(PD)	0000E 00
36312.4751	0000E 001(PD)	0000E 00
36316.2351	0000E 001(PD)	0000E 00
36319.9951	0000E 001(PD)	0000E 00
36323.7551	0000E 001(PD)	0000E 00
36327.5151	0000E 001(PD)	0000E 00
36331.2751	0000E 001(PD)	0000E 00
36335.0351	0000E 001(PD)	0000E 00
36338.7951	0000E 001(PD)	0000E 00
36342.5551	0000E 001(PD)	0000E 00
36346.3151	0000E 001(PD)	0000E 00
36350.0751	0000E 001(PD)	0000E 00
36353.8351	0000E 001(PD)	0000E 00
36357.5951	0000E 001(PD)	0000E 00
36361.3551	0000E 001(PD)	0000E 00
36365.1151	0000E 001(PD)	0000E 00
36368.8751	0000E 001(PD)	0000E 00
36372.6351	0000E 001(PD)	0000E 00
36376.3951	0000E 001(PD)	0000E 00
36380.1551	0000E 001(PD)	0000E 00
36383.9151	0000E 001(PD)	0000E 00
36387.6751	0000E 001(PD)	0000E 00
36391.4351	0000E 001(PD)	0000E 00
36395.1951	0000E 001(PD)	0000E 00
36398.9551	0000E 001(PD)	0000E 00
36402.7151	0000E 001(PD)	0000E 00
36406.4751	0000E 001(PD)	0000E 00
36410.2351	0000E 001(PD)	0000E 00
36413.9951	0000E 001(PD)	0000E 00
36417.7551	0000E 001(PD)	0000E 00
36421.5151	0000E 001(PD)	0000E 00
36425.2751	0000E 001(PD)	0000E 00
36429.0351	0000E 001(PD)	0000E 00
36432.7951	0000E 001(PD)	0000E 00
36436.5551	0000E 001(PD)	0000E 00
36440.3151	0000E 001(PD)	0000E 00
36444.0751	0000E 001(PD)	0000E 00
36447.8351	0000E 001(PD)	0000E 00
36451.5951	0000E 001(PD)	0000E 00
36455.3551	0000E 001(PD)	0000E 00
36459.1151	0000E 001(PD)	0000E 00
36462.8751	0000E 001(PD)	0000E 00
36466.6351	0000E 001(PD)	0000E 00
36470.3951	0000E 001(PD)	0000E 00
36474.1551	0000E 001(PD)	0000E 00
36477.9151	0000E 001(PD)	0000E 00
36481.6751	0000E 001(PD)	0000E 00
36485.4351	0000E 001(PD)	0000E 00
36489.1951	0000E 001(PD)	0000E 00
36492.9551	0000E 001(PD)	0000E 00
36496.7151	0000E 001(PD)	0000E 00
36500.4751	0000E 001(PD)	0000E 00
36504.2351	0000E 001(PD)	0000E 00
36507.9951	0000E 001(PD)	0000E 00
36511.7551	0000E 001(PD)	0000E 00
36515.5151	0000E 001(PD)	0000E 00
36519.2751	0000E 001(PD)	0000E 00
36523.0351	0000E 001(PD)	0000E 00
36526.7951	0000E 001(PD)	0000E 00
36530.5551	0000E 001(PD)	0000E 00
36534.3151	0000E 001(PD)	0000E 00
36538.0751	0000E 001(PD)	0000E 00
36541.8351	0000E 001(PD)	0000E 00
36545.5951	0000E 001(PD)	0000E 00
36549.3551	0000E 001(PD)	0000E 00
36553.1151	0000E 001(PD)	0000E 00
36556.8751	0000E 001(PD)	0000E 00
36560.6351	0000E 001(PD)	0000E 00
36564.3951	0000E 001(PD)	0000E 00
36568.1551	0000E 001(PD)	0000E 00
36571.9151	0000E 001(PD)	0000E 00
36575.6751	0000E 001(PD)	0000E 00
36579.4351	0000E 001(PD)	0000E 00
36583.1951	0000E 001(PD)	0000E 00
36586.9551	0000E 001(PD)	0000E 00
36590.7151	0000E 001(PD)	0000E 00
36594.4751	0000E 001(PD)	0000E 00
36598.2351	0000E 001(PD)	0000E 00
36601.9951	0000E 001(PD)	0000E 00
36605.7551	0000E 001(PD)	0000E 00
36609.5151	0000E 001(PD)	0000E 00
36613.2751	0000E 001(PD)	0000E 00
36617.0351	0000E 001(PD)	0000E 00
36620.7951	0000E 001(PD)	0000E 00
36624.5551	0000E 001(PD)	0000E 00
36628.3151	0000E 001(PD)	0000E 00
36632.0751	0000E 001(PD)	0000E 00
36635.8351	0000E 001(PD)	0000E 00
36639.5951	0000E 001(PD)	0000E 00
36643.3551	0000E 001(PD)	0000E 00
36647.1151	0000E 001(PD)	0000E 00
36650.8751	0000E 001(PD)	0000E 00
36654.6351	0000E 001(PD)	0000E 00
36658.3951	0000E 001(PD)	0000E 00
36662.1551	0000E 001(PD)	0000E 00
36665.9151	0000E 001(PD)	0000E 00
36669.6751	0000E 001(PD)	0000E 00
36673.4351	0000E 001(PD)	0000E 00
36677.1951	0000E 001(PD)	0000E 00
36680.9551	0000E 001(PD)	0000E 00
36684.7151	0000E 001(PD)	0000E 00
36688.4751	0000E 001(PD)	0000E 00
36692.2351	0000E 001(PD)	0000E 00
36695.9951	0000E 001(PD)	0000E 00
36699.7551	0000E 001(PD)	0000E 00
36703.5151	0000E 001(PD)	0000E 00
36707.2751	0000E 001(PD)	0000E 00
36711.0351	0000E 001(PD)	0000E 00
36714.7951	0000E 001(PD)	0000E 00
36718.5551	0000E 001(PD)	0000E 00
36722.3151	0000E 001(PD)	0000E 00
36726.0751	0000E 001(PD)	0000E 00
36729.8351	0000E 001(PD)	0000E 00
36733.5951	0000E 001(PD)	0000E 00
36737.3551	0000E 001(PD)	0000E 00
36741.1151	0000E 001(PD)	0000E 00
36744.8751	0000E 001(PD)	0000E 00
36748.6351	0000E 001(PD)	0000E 00
36752.3951	0000E 001(PD)	0000E 00
36756.1551	0000E 001(PD)	0000E 00
36759.9151	0000E 001(PD)	0000E 00
36763.6751	0000E 001(PD)	0000E 00
36767.4351	0000E 001(PD)	0000E 00
36771.1951	0000E 001(PD)	0000E 00
36774.9551	0000E 001(PD)	0000E 00
36778.7151	0000E 001(PD)	0000E 00
36782.4751	0000E 001(PD)	0000E 00
36786.2351	0000E 001(PD)	0000E 00
36789.9951	0000E 001(PD)	0000E 00
36793.7551	0000E 001(PD)	0000E 00
36797.5151	0000E 001(PD)	0000E 00
36801.2751	0000E 001(PD)	0000E 00
36805.0351	0000E 001(PD)	0000E 00
36808.7951	0000E 001(PD)	0000E 00
36812.5551	0000E 001(PD)	0000E 00
36816.3151	0000E 001(PD)	0000E 00
36819.0751	0000E 001(PD)	0000E 00
36822.8351	0000E 001(PD)	0000E 00
36826.5951	0000E 001(PD)	0000E 00
36830.3551	0000E 001(PD)	0000E 00
36834.1151	0000E 001(PD)	0000E 00
36837.8751	0000E 001(PD)	0000E 00
36841.6351	0000E 001(PD)	0000E 00
36845.3951	0000E 001(PD)	0000E 00
36849.1551	0000E 001(PD)	0000E 00
36852.9151	0000E 001(PD)	0000E 00
36856.6751	0000E 001(PD)	0000E 00
36860.4351	0000E 001(PD)	0000E 00
36864.1951	0000E 001(PD)	0000E 00
36867.9551	0000E 001(PD)	0000E 00
36871.7151	0000E 001(PD)	0000E 00
36875.4751	0000E 001(PD)	0000E 00
36879.2351	0000E 001(PD)	0000E 00
36882.9951	0000E 001(PD)	0000E 00
36886.7551	0000E 001(PD)	0000E 00
36890.5151	0000E 001(PD)	0000E 00
36894.2751	0000E 001(PD)	0000E 00
36898.0351	0000E 001(PD)	0000E 00
36901.7951	0000E 001(PD)	0000E 00
36905.5551	0000E 001(PD)	0000E 00
36909.3151	0000E 001(PD)	0000E 00
36913.0751	0000E 001(PD)	0000E 00
36916.8351	0000E 001(PD)	0000E 00
36920.5951	0000E 001(PD)	0000E 00
36924.3551	0000E 001(PD)	0000E 00
36928.1151	0000E 001(PD)	0000E 00
36931.8751	0000E 001(PD)	0000E 00
36935.6351	0000E 001(PD)	0000E 00
36939.3951	0000E 001(PD)	0000E 00
36943.1551	0000E 001(PD)	0000E 00
36946.9151	0000E 001(PD)	0000E 00
36950.6751	0000E 001(PD)	0000E 00
36954.4351	0000E 001(PD)	0000E 00
36958.1951	0000E 001(PD)	0000E 00
36961.9551	0000E 001(PD)	0000E 00
36965.7151	0	

STAT	N	RMS RMS/SIG	TYPE	N	RMS RMS/SIG	TYPE	N	RMS RMS/SIG	TYPE
MH	206	.181216E+01 .286209E+02	(RD)	63	.393518E+03 .171393E+02	(R)			
BD	116	.196791E+01 .324953E+02	(RD)	26	.268186E+03 .116806E+02	(R)			
BH	119	.202287E+01 .394027E+02	(RD)	26	.268868E+03 .117103E+02	(R)			

(21)

Figure 30. RMS Summary

Figure 31. Results of Iterations

ITERATION 1 (22)
56 DATA POINTS WERE USED IN THE SOLUTION (23)
CURRENT SOLUTION IS BEST SO FAR (24)

CURRENT SOLUTION IS

ALPHA	DELTA	BETA	A	R	V
-23116540E+02	-26515166E+02	-89889770E+02	-45733120E+02	-24780837E+08	-23765259E+05
GM	J2	J3			
-28490000E-00	-55304203E-02	-10826450E-02	-25460000E-05		

CURRENT SOLUTION (TOTAL MACHINE UNITS)

74721354573221420	544320606644204360
146124822171017100	1705615702466762520
710736323265026060	4706747423362016360
1132533374653222010	

FOR THIS SOLUTION (27)

CORRECTIONS

-25207767E-02	-48463704E-04	-85928347E-04	-49035265E-03	-60568054E+02	-21986359E-01 (28)
-99368143E-01	-66223787E-08	-47399442E-09	-47709546E-09		

BOUNDS

-15000000E+01	-15000000E+01	-30000000E-00	-75000000E+00	-49200000E+04	-49200000E+03 (29)
-15000000E-00	-10000000E-07	-10000000E-07	-10000000E-07		

HITTING BOUNDS (30)

NEXT SOLUTION IS

-23117061E+02	-26515112E+02	-89889684E+02	-45733110E+02	-24780897E+08	-23765261E+05 (31)
-28490000E-00	-55304203E-02	-10826450E-02	-25460000E-05		

NEXT SOLUTION (TOTAL MACHINE UNITS)

747213545732214200	544320606644204360
146124822171017100	1705615702466762520
710736323265026060	4706747423362016360
1132533374653222010	

PREDICTED RMS - 30560428E+00 FOR NEXT SOLUTION (33)

PARAMETERS FOR NORMALIZED DATA

1	2	3	4	5	6
ALPHA	DELTA	BETA	A	R	V
-23116540E+02	-26515166E+02	-89889770E+02	-45733120E+02	-24780837E+08	-23765259E+05
GM	J2	J3			
-28490000E-00	-55304203E-02	-10826450E-02	-25460000E-05		

CORRELATION MATRIX

1.091271E-06
 -1.002007E-06 1.135765E-06
 1.425805E-07 1.474110E-07 5.741945E-07
 4.203503E-07 9.346497E-07 8.069704E-07 2.583372E-06
 1.690322E-01 7.402335E-02 2.600643E-02 1.765453E-01 5.759726E+04
 8.433958E-08 3.555130E-05 4.874953E-05 1.493846E-04 2.963530E+01 2.590916E-02
 6.788504E-03 1.003945E-02 3.786042E-02 3.947345E-02 1.793855E+03 1.355247E+03 4.182627E+03
 6.947884E-11 1.849656E-11 3.954538E-12 9.345449E-11 2.894611E-05 1.791861E-08 1.926069E-06 1.6322C9E-14
 9.141134E-09 7.329911E-09 2.514224E-08 3.183901E-08 2.461613E-03 8.703271E-07 1.986753E-03 1.183892E-12
 -1.859117E-10 1.983325E-09 2.018024E-08 2.046730E-08 1.300181E-03 1.326400E-04 1.612694E-03 6.072769E-13
 (37)

1.210931E-09
 -9.307211E-10 7.812334E-10

ATA INVERSE (OCTAL OUTPUT UNITS)

7627324031360
 454463257330 463402605700
 156771211000 0244261375702261253516500
 44003652217501407437724700645264324067057745315236C0
 6611054101620143357033230334457127666024132265633205203657525560
 73501225650404723344535170 31747724435407722366334050604310335007343662460120
 20614737647404402202695303416644534710 50354151786603275057056510 567051705225608522076780
 106756503440243614571255032403130250602150012760320123800330746033426616030401473634530438412614753295C0
 310330117370024503276364570 27367207570072707537171103012571334220 330746254610466660717647506160326137120
 376634002433030123775345302671472757750 04460253532026500C6410670657672651704010277511437408724C31762210

5656504342260
 95310146071706322364477460

SQUARE ROOT OF DIAGONAL OF INVERSE
 1.0446E-03 1.0657E-03 7.5776E-04 1.6073E-03 2.3999E+02 1.6096E-01 6.4673E+01 1.2776E-07
 3.4798E-05 2.7951E-05
 CAME FROM SEGMENT 15 ARE IN SEGMENT 62 FUNCTION IS 0
 OLD FUNCTION IS 2 NEW FUNCTION IS 0
 CAME FROM SEGMENT 62 ARE IN SEGMENT 63 FUNCTION IS 0

Figure 31 (cont.)

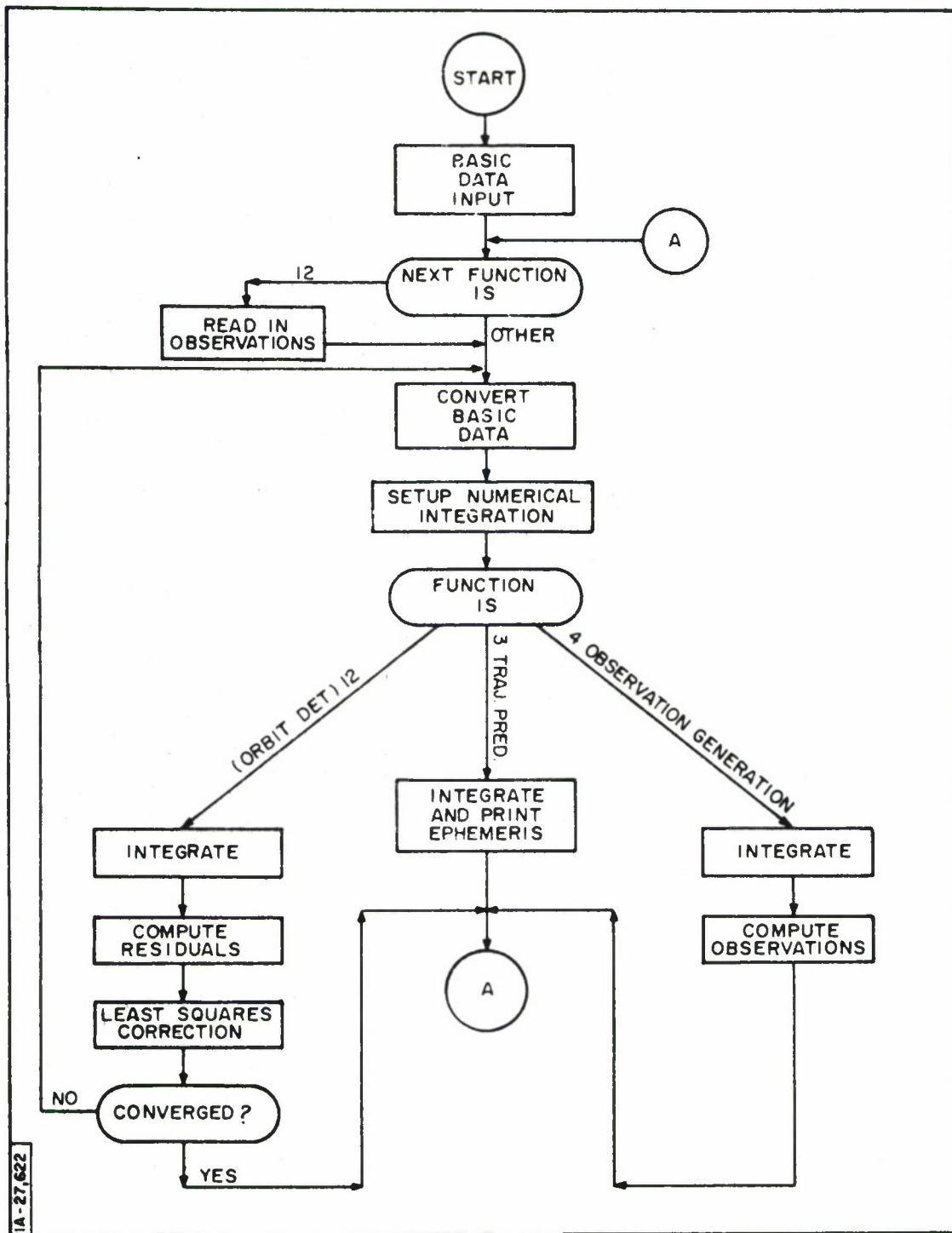


Figure 32. General TRACE-D Flow Chart

Section 5.

Programming Information

5.1 Structures and Flowcharts

Figures 32 and 33 are both flowcharts of the TRACE-D program; however, each is geared to a different level of description. Figure 32 depicts program paths determined by the function to be performed with only basic operations considered, while Figure 33 presents pertinent programming details also.

Since the TRACE-D program is extremely large (approximately 22,000 source language cards) and can not be fully contained in core, the segmentation mode of operation is employed whereby the program becomes several coreloads. Figure 33 shows the levels of segmentation employed and the makeup of each and every segment. The fact that only the segments along a single vertical path are in core at any one point in time solves the storage program.

The number appearing outside each segment block in Figure 33 serves to identify its level and position in the structure. Those subroutine names underlined are the control programs, which among other things, transfer control to the proper segments for each major function.

5.2 Tape Usage

The TRACE-D program employs many tapes to handle input-output data as well as intermediate calculations. The tape requirements for each option consists of a basic set common to all functions (listed in Table 11) plus a unique option-dependent set. All of the possible option-dependent tapes are listed in Tables 12, 13, 14 and those that are mandatory are appropriately marked. Please note that no more than five tapes from Table 14 may be used in one run (in addition to the basic set, of course).

The above description has been included for completeness; however, as previously mentioned, the user may obtain a running deck

for any option he wishes to choose which will set up all appropriate tapes for him.

Table 11.
Basic Set of Tapes

TAPE NUMBER	NAME	FUNCTION
	LIB1	Program tape #1
	LIB2	Program tape #2
2		System Input Tape
3		System Output Tape
4	PTAPE*	Necessary Scratch Tape
3		Necessary Scratch Tape

* This is a necessary input quantity for all runs.

Table 12.
Trajectory Prediction Tapes

TAPE NUMBER	NAME	FUNCTION
7	CTAPE	Planetary Coordinate Tape
17	NTAPE	Binary trajectory tape (nominal) for trajectory differencing (program generated).
19	DTAPE	Binary difference tape for trajectory differencing.
15		A binary trajectory tape generated by the program and saved.

Table 13.

Observation Generation Tapes

TAPE NUMBER	NAME	FUNCTION
11	ETAPE	BCD tape of observations program generated.
7	CTAPE	Planetary tape
10	IFLAG(16)*	Scratch tape (for trajectory)

* Necessary tape for this option.

Table 14.

Orbit Determination Tapes

TAPE NUMBER	NAME	FUNCTION
11	IBCDI	BCD tape of observations
12	IBINI	Binary tape of compacted observations
7	CTAPE	Planetary coordinate tape
9*		Scratch tape (for normal matrix)
5*		Necessary scratch tape
10*		Scratch tape (trajectory)

* Necessary tapes for this option

5.3 Subroutines

This section is devoted to a complete listing of every subroutine in TRACE-D with a functional description and other pertinent facts also given. In some cases two or more routines are identical in function and differ only slightly in name. This is due to the segmentation rule that the same routine name cannot appear in more than one logical path (i.e., one complete coreload). Therefore, since some routines were needed in more than one path only the names were changed not the content. The routines are listed alphabetically in Table 15 and the information given is self-explanatory.

Table 15.
Subroutine Listing

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	D	A	T	A	J	P	G				
A2XY	62	x	x									INCN, INCN1, KICS, ISET	BADY	Converts orbital elements to car- tesian coordinates	312
ACE	01	x										TRAIN DUM	QUEEN	Sets up the code lists for all radar parameters	1212
ALADD	13	x	x									TRACK, TRAJ, TRAJ3,		Adds longitude in- dependent terms to the variation- al equations for alpha	141
ALPHAG	63	x	x											Computes right as- cension at Green- wich at 0 hours of given Julian date	133
AND	63	x	x											Logical "AND" func- tion for two variables	14
APSIS	22	x	x									TRAJ, TRAJ3	CALD, NTRP, SHUFL	Interpolates for and prints lati- tude, longitude and altitude when BETA = 90°	503

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	N				
APSYS2	23										x	TRACK	NTRP	Same as APSIS	422
ASIN/ ACOS	63										x	PTRAJ		Computes arcsine and arccosine	141
ASPECT	05										x	SITE	XY2R	Computes aspect angles	471
ATAL	05										x	BABT		Finds I, J ele- ments of matrix	116
ATM59	03										x	ATM5D, LJAT		Computes atmos- pheric density	543
ATM5D	03										x	PERT	ATM59, LJAT	Channels density evaluation to appropriate routine	115
AXB3	11										x	INV3		Solves the system AX=B using Cramer's Rule	205
BABT	06											SITE		Computes BABT where B and A appropri- ate matrices	241
BADY	62											A2XY		Computes solution of two-body problem	1000
BLN	01										x	NAMLR		Performs data coding	401
BL	25										x	REST, RESTI		Finds I, J element of matrix in spe- cial format	111

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	R	B	D	E	T	R	A	J	P	R	E	N	
BNZI	02	x												Converts and prints bounds and sigmas	251
BSET	16									x				Sets up headings and labels	341
BVDS	06										x			Builds variable data formats	203
CALD	62												IDPC, AND	Computes complete date from Julian date	216
CDLN	12	x						x				INITB, HNDL, PTRAJ, ORPT, RADT, TRAJ, WZRD		Computes data loca- tion from BCD name	210
CDX	11	x										RSORT	IDPUV	Packs data into one word	100
CHAIN	63	x						x				MAIN1	INPUT, CSET, DJULA, ALPHAG NEWPAR, ITIN	Control program for segment 63	607
CHBDS	25	x										LEAST		Modifies bounds for orbit determination	120
CMCOEF	02	x										INITA		Computes coefficients for dynamic station location constraints	1031

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	G	E	N		
CMPA	05	x											PHI	Computes azimuth partials and resi- dual	456
CMPA	05	x												Computes topocen- tric declination partials and resi- dual	623
CMPDG	05	x												Computes geocentric declination par- tials and residuals	364
CMPE	05	x											PHI, CMPR	Computes elevation partials and resi- duals	626
CMPLR	05	x												Computes little residuals and par- tials	451
CMPN	06									x				Computes noise	136
CM PQ	05	x											CMPR, FILL	Computes P and O partials and resi- duals	476
CM PQD	05	x											CMPRD, FILL	Computes P and O partials and resi- duals	500
CM PR	05	x												Computes range par- partials and resi- duals	530

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTIONS	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	G				
CMPRD	05	x										SITE	PHI	Computes range rate partials and residuals	734
CMPRG	05	x										SITE		Computes right ascen- sion partials and residuals	340
CMPRH	05	x										SITE		Computes topocentric RA, HA partials and residuals	636
CMPUV	05	x										SITE		Computes U, V par- tials and residuals	606
CMXYZ	05	x										SITE		Computes X, Y, Z partials and resi- duals	514
CNV	25	x										LEAST		Checks for conver- gence in orbit de- termination mode	144
CODE	11	x										CSCP	IDPUV	Packs data into one word	142
COORD	03	x									x	PERT		Reads JPL tape and performs interpo- lation	606
CPPR	22										x	TRAJ3	DIFF, PRXI, PRELM, PTRAJ	Controls output during trajectory prediction	143

Table 15 (cont.)

NAME	SEGMENT NU NUMBER	USED IN										ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	D	
CRASH	03	x	x	x								447
CSCP	11	x										1174
CSET	63	x	x	x								135
DAPT	11	x										217
DATY	12	x	x	x								276
DAUX	03	x	x	x								270
DCDX	11											107
DCODE	62	x	x	x								141
DECDE	06											133
FUNCTIONS												
CALLS SUBROUTINES												
CALLED BY SUBROUTINES												
ROUTINE SIZE												
Tests for vehicle below critical altitude Compacts and codes data Sets up some constants Prints deleted observations Prints data types used in partial generation Computes derivatives for equations of motion and variational equations Decodes a data word coded by CDX Decodes words coded by CODE Decodes packet data word												
NTRP, HDOT TCDE, DCDX, REPL, IDPC TCDE DECD MOVE, PERT, MATVEC, GRAV2 IXTUV IXTUV IXTUV												
TRACK, TRAJ, TRAJ3 TRAIN CHAIN, TSET, SIFT DUM CSCP, RSORT, TROUT, KICS, SUMP, DATY												

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTIONS	ROUTINE SIZE
		O	T	R	A	T	D	A	T	A	G	E	N		
DECD	12	x	x										IXTUV	Same as DECDE	133
DESA	06												PRDCT	Keeps simulation list current	273
DEQ2	03	x	x										DAUX	Performs inte- gration	1472
DFDB	13	x	x										NOB, DFDB1 MATVEC	Computes non- homogeneous terms for vari- ational equations	376
DFDB1	13	x	x											Same as DFDB	723
DIFF	31	x	x												750
DJULA	63	x	x										HUMAH2	Computes Julian date	177
DUM	12	x	x										ACE, DATY, ITEST, REPL, CDLN, ECDA, PUTPO	Reads station data and stores it	1045
DXDA1	31													Computes partials of pos and vel wrt orbital elements	355
DXDA	12	x	x											Same as DXDA1	355
DXDRSR	12	x	x											Computes partials of pos and vel wrt spherical coordi- nates	342

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	N				
DXDRS	21	x										TSET3		Same as DXDRSR	342
ECDA	12	x	x								x	DUM	IDPU, IXTC	Codes an array	155
ECTR	63	x	x								x	CHAIN,	ITEST	Codes an array	253
EXBLN	63	x	x								x	INCNI		Extract routine	123
FBIN	63	x	x								x	INPUT		Conversion rou- tine	305
FDPC	63	x	x								x	INPUT		Deposit routine	35
FEQX	13	x									x			Generates a matrix	183
FILL	15	x										RADR, CMPQ CMPQD	IXTUV, UTRD	Fills a list for partials compu- tation	533
FIND	13	x									x	PERT		Performs linear interpolation	242
FINTR	31										x	MAINE		Used to end a trajectory run	360
FIOD	64	x									x			Sets up appropri- ate magnetic tapes	14000
FITA	21	x										FMGA	ISSET1, ITIN TSET3, TRAJ TBIAS1	Control routine for segment 21	1472
FITB	15	x										MAIN1	NTRP, LEAST	Control routine for segment 15	663
FMGA	13	x									x	MAIN1	FITA, GAINA MAINE	Control routine for segment 13	202

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	N				
FUTC	63	x	x									INPUT		Extract character routine	35
GAINA	23										x	FMGA	TRACK	Control routine for segment 23	1266
GAINB	06										x	MAIN1	RIST, SITE, TRAJG, HNDL, WZRP, DESA, ITIN	Control routine for segment 06	320
GAUSS	11										x	KICS		Determines elliptic elements given 2 points	652
GRAV														Computes acceleration components due to geopotential	
GRAV1	13	x	x								x	DAUX, PERT, TSET2, TSET4		Computes \dot{H} and \ddot{H} for minimum and maximum altitude interpolation	470
GRAV3												CRASH, SITR		Sets up page headers for observations	
HDOT	13	x	x								x			Controls observation output	301
HDRS	16										x	HNDL	DECDE		410
HNDL	16										x	GAING, TRAJG	BSET, BVDS, CALD, HDRS, WHDR		1351

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	R	T	D	A	T	R	A	J	P	R	E		
HUM1	06													Input-output conversion	474
HUM1	02	x												Input-output conversion	474
HUM1	25	x												Input-output conversion	474
HUM1	31													Input-output conversion	327
LAND	63	x												Logical and function	
IBCD	63	x												Conversion routine	
IBIN	63	x												Conversion routine	
IDPC	63	x												Conversion routine	
IDPUV	63	x												Deposit routines	
INC1	02	x												Initializes input	766
INC1	02	x												Initializes input	1245

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN											CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	D	R	A	T	A	J	P	G	E				
INITA	02	x	x	x	x	x	x	x	x	x	x	x	MAIN1	INCN	Control routine for segment 02	525
INITB	12	x	x	x	x	x	x	x	x	x	x	x	INITB	DUM, TCDE, CALD, PREL, REST, NAMER	Control routine for segment 12	360
INPAL	02	x	x	x	x	x	x	x	x	x	x	x	INITA		Checks for incor- rect input	261
INPUT	63	x	x	x	x	x	x	x	x	x	x	x	CHAIN	IXTC, IBIN, FBIN	Reads in and stores all in- put	1662
INSERT	63	x	x	x	x	x	x	x	x	x	x	x	INPUT	INPUV	Inserts charac- ter information words	102
INV3	11	x	x	x	x	x	x	x	x	x	x	x	TROUT1	AXB3	Computes noise	108
IOR	63	x	x	x	x	x	x	x	x	x	x	x	INPUT		Logical function	
ITEST	63	x	x	x	x	x	x	x	x	x	x	x	INPUT		Tests for certain character config- urations	117
ITIN	63	x	x	x	x	x	x	x	x	x	x	x	CHAIN		Checks the next function code in list and sets indicator	106
IXTC	63	x	x	x	x	x	x	x	x	x	x	x	INPUT		Extract routine for characters	
IXTUV	63	x	x	x	x	x	x	x	x	x	x	x	INPUT		Extract routine	
KEPLER	22	x	x	x	x	x	x	x	x	x	x	x	TRAJ3		Solves Keplers equation	160

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	T	F	R	B	D	J	P	G	E	N
KICS	11	x												Computes initial conditions from 2 R, A, E sets	505
KTIM	03	x		x										Tests for orbit adjusts times Latitude print routine	
LATPR	31							x					NTRP, LDOT	Accumulates ATA matrix and re- siduals	
LAYR	15	x												Computes longi- tude and rate of longitude	163
LDOT	22							x						Control routine for segment 32	578
LEAST	32	x											SAVEN, SLV, LSTP, RECVR, TCDE, ITIN, SIGMA, SACR, SACT, PATTY, CNV		
LEGSA	32	x										SLV		Solves AX=B in least squares sense	1355
LJAT	03	x										ATMMD	ATM59	Compute density for Lockheed Jacchia	564

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	N				
LSTP	32	x										LEAST	HUMAH1	Controls output for least squares	1125
LUBS	16							x				SITE		Checks data genera- tion indicators	155
MAIN1	62	x					x					MAIN Prog	INITA, FITB, TINITB, FMGA, GAINB	Control routine for segment 62	516
MAINE	31						x					FMGA	ITIN, FINTR SPEC, TSET2 TRAJ3	Control routine for segment 32	1322
MATMAT	13	x					x				x	DAUX, DFDB DFDB1		Computes AB+C	114
MATVEC	13	x					x				x	REINT, REINT2		Computes matrix times vector product	111
MOVE	13	x					x				x	DAUX, TRAJ TRAJ3, TSET2		Moves data from one array to another	267
MOVE2	23										x	TRACK, TSET4		Same as MOVE	236
NAMER	01	x					x				x	TRAIN, INITB, CHAIN, INCNI	INSERT	Finds list of names for output Decodes parameter list	230
NEWPAR	63	x					x				x				561

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	N				
NOB	62	x	x	x	x	x	x	x	x	x	x	DFDB, INCN, INC1, SACT		Finds correct geo- potential coefficient	141
NODE	23										x	TRACK	NTRP	Interpolates for nodal crossings	252
NTRP	62	x		x			x				x	CRASH, FILL, FITB, TRAJ, TRAJ3, TRAJG		Interpolation routine	371
OR PATTY	63 32	x	x	x			x				x	INPUT LEAST	XRAY	Logical or function Prints ATA and in- verse	1231
PERT	03	x		x			x				x	DAUX	ATMMD, COORD, DFDB, FEQX, GRAV, TMATX VMATX	Computes perturba- tive accelerations	641
PHI	15	x										CMPE, CMPE CMPRD		Computes station coordinate quan- tities	126
PRDCT	16										x	DESA	TRAJG, XY2A, IXTUV	Predicts rise and set times	571
PREL	12	x									x	INITB	XY2A	Computes and prints elements	427
PRELM	22	x									x	CPPR		Generates print times	345
PRGEN	13	x									x	TRAJ, TRAJ3 TSET2			

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	R	T	R	A	D	B	A	T	D				
PRXI	22				x							CPPR	HUMAH2	Prints partial derivatives Dummy routine	262
PSET	03		x		x							INITA			50
PTRAT	22				x							CPPR	CALD, SPEC, XY2R, ITEST	Prints trajec- tory	1216
PUTPQ	01			x								TRAIN, DUM		Sets up station codes	115
QUEEN	01		x									ACE		Sets up code list for parameters	140
R2XY	62		x		x							INCN, TSET		Converts spheri- cal to cartesian coordinates	257
RADR	15							x				TSET3 FITB	SUMP, CMPA, CMPRG, TCDE FILL, CMPE, CMPQ, SIGMA CALD, ITEST	Controls partial and residual computation	1233
RADT	15		x									RADR		Residual output routine	741
RDM	16								x			GAINB		Random number generators	10
RDMIN	16								x			RDM		Recovers old matrix from tape	10
RECVR	25							x				LEAST			135
REINT	13		x									TRAJ TRAJ3	MATVEC	Reinitializes for thrusts and kicks	456

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	N				
REINT2	23										x	TRACK		Same as REINT	540
REPL	01	x										CSCP, DUM TRAIN SLV		Replaces word by an integer Prepares bounds and ATA for constraints Modifies solu- tion for constraints	153
REST	25	x													153
REST1	25	x										SLV			250
RIST	16										x	GAINB	NTRP, WRKK, IXTUV	Checks for vehi- cle visibility Finds I, J ele- ment of inverse matrix	630
RLI	25	x										REST1			103
RL	06										x	BABT		Same as RLL	103
RKDT	06										x	SITE		Computes range and range rate for station N	224
RSET	12	x									x	INITB	STANG	Computes stored quantities for RADR	125
RSORT	11	x										TRAIN	CDX, BCDX	Sorts data	317
SACR	32	x										LEAST	TCDE	Corrects radar parameters	244
SACT	32	x										LEAST	NOB	Corrects trajec- tory parameters	233

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	G	E	N		
SAVEN	32	x												Saves old matrix on tape	135
SHUFLE	06													{ Shuffles two data list	116
SHUFL	13	x	x												117
SIFT	11	x											IXTUV, DAPT	Second difference editing routine	522
SIGMA	15	x												Finds correct sigma for station L	157
SITE	16													Decodes parameter words for data generation	2443
SLV	32	x												Solves normal equations	204
SPEC	31													Write special tra- jectory tape	340
STANG	01	x												Computes station data	137
STIR	31		x											Interpolates for special trajectory print times	266
SUMP	62	x	x											Codes data words	237
TBIAS	15	x												Computes time bias for each station	217

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	D	R	A	A	T	A	G	E	N			
TBIAS1	21	x											SUMP, LXTUV	Same as TBIAS	217
TCDE	62	x	x										INITB,	Decodes date	101
TINITB	01	x											TRAIN	Control routine for segment 01	227
TMATX	13	x												Calculates T matrix for varia- tional equations	236
TRAIN	11	x											KICS, SIFT, ACE, PUTPQ, REPL, TROUT RSORT, INPUT, STANG, ZRRIT	Control routine for segment 11	1330
TRACK	23	x												Generates trajec- tory tape for data generation	453
TRAJ3	31		x										MOVE, NRP, APSYS, KTIM, CPFR, SHUFL, DEQ2, STIR, PRGEN, CRASH, TSET2 DXDA1	Controls integra- tion in trajectory prediction mode	1010

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN								CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	T	A	D	E				
TRAJ	21	x								FITA	NTRP, MOVE CALL, REINT KTIM, TSET1 CRASH, ALADD, PRGEN, TRIM, NTRP, SHUFLE	Controls integra- gration in orbit determination mode	1033
TRAJG	16							x		GAINB, PRDCT		Reads trajectory from tape for data generation	267
TRIM	16							x		TRAJG		Computes yaw, roll and pitch corrections	152
TROUT	11								x	TRAIN	TCDE, EXIT, DCDX, IXTUV TROUT1, DJULA, ALPHAG, INV3	Tracking data out- put routine	1047
TROUT1	11								x	TROUT		Tracking covari- ance matrix set- up and output routine	313
TSET	12								x	INITB	CSET, DXDA, A2XY, XY2A, DXDRSR, R2XY	Initializes inte- gration	514

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	D				
TSET1	21	x										FITA, TRAJ	DAUX, DEQ2, GRAV1, MOVE, PRGEN, SHUFL	Initializes inte- gration for orbit determination	403
TSET2	31		x									MAINE, TRAJ3	DAUX, DEQ2, MOVE, GRAV1 SHUFL	Initializes inte- gration for tra- jectory prediction	344
TSET3	21	x										FITA	R2XY, DXDRS	Initializes inte- gration for mul- tiple vehicles	262
TSET4	23						x					TRACK	DAUX, DEQ2, GRAV1, MOVE2	Initializes inte- gration for data generation	331
UNVEC	62	x	x				x					TRAJ, RADT PERT		Computes unit vector	
VMATX	03	x											MATMAT	Calculates matrix for variational equations	263
WHDR	16						x					HNDL		Writes header page	255
WRKR	16						x					RIST, SITE		Controlled output routine	172
WZRD	16						x					GAINB, TRAJG, SITE	CALD, IXTUV	Data generation routine	
XRAY	32	x										PATTY	HUMAH1	Converts units of ATA	172

Table 15 (cont.)

NAME	SEGMENT NUMBER	USED IN										CALLED BY SUBROUTINES	CALLS SUBROUTINES	FUNCTION	ROUTINE SIZE
		O	T	R	A	D	R	A	T	A	G	E	N		
XY2A	62	x	x	x	x	x								Converts rectangular coordinates to elliptical	412
XY2R	62	x	x	x	x	x								Converts rectangular coordinates to spherical	225
YNTL	02	x	x	x	x	x								Output initial conditions and constants	3713
ZRRIT	11	x											SUMP	Sets up sigmas for zero residuals	240

5.4 Variable Lists

In this section are listed several variable arrays used in the TRACE-D program. These particular variables were chosen because they are the most important and critical storage areas of TRACE-D. They contain all of the indicators and input that dictate the logical program flow.

Table 16. NUMB ARRAY

NUMB	NUMBER OF	SET IN	INPUT NAME
1	RADAR STATIONS	TRAIN	
2	OBSERVATION TIMES	TRAIN	
	OR STATIONS REQUIRING SIGHTING EPHEMERIS DATA	DUM	
	OR STATIONS REQUIRING SIMULATION DATA	DUM	
3	WORDS IN COMPACTED RADAR OBSERVATION LIST - TOTAL	TRAIN	
4	WORDS OF COMPACTED RADAR OBSERVATIONS IN CORE NOW	TRAIN	
5	DIFFERENTIAL EQUATION PARAMETERS TO BE SOLVED FOR	CHAIN	
6	INITIAL CONDITION PARAMETERS TO BE SOLVED FOR	CHAIN	
7	RADAR STATION PARAMETERS TO BE SOLVED FOR	KING	
8	RADAR OBSERVATION PARAMETERS TO BE SOLVED FOR	KING	
9	PROGRAM TAPE UNIT	CHAIN -	PTAPE
10	MAXIMUM ITERATIONS ALLOWED	CHAIN -	MAXIT
11	TOTAL PARAMETERS (SUM OF 5,6,7 AND 8)	TRAIN	
12	TRAJECTORY PARAMETERS (SUM OF 5 AND 6)	TRAIN	
13	OBSERVATIONS (TOTAL NUMBER OF MEASUREMENTS)	TRAIN	
14	PRESENT ITERATION		
15	BASIC TYPES OF OBSERVATIONS		
16	SIZE OF BUFFERS IN DEAN (Q DATA) - IF = 0, SET TO 5000	CHAIN	
17	TOTAL RADAR PARAMETERS (SUM OF 7 AND 8)	DEAN	
18	TAPE UNIT FOR PLANETARY COORDINATE TAPE	TRAIN	
19	SECOND ORDER DIFFERENTIAL EQUATIONS BEING INTEGRATED (3*(1+NUMB(12)*IFLAG(8)))	CHAIN -	CTAPE
20	POSSIBLE KINDS OF RADAR PARAMETERS (LAT, LONG, HEIGHT, AND BIASES)	INCN	
21	WORDS IN CORE FOR SIGHTING EPHEMERIS BUCKET	CHAIN	
22	POSSIBLE KINDS OF SIGHTING DATA	CHAIN	
23	DATA NOISE CONTROL (ZERO FOR NO NOISE, NON-ZERO STARTS RANDOM NUMBER GENERATORS FOR DATA NOISE)	CHAIN -	NOISE
24	POSITION IN ITIN LIST OF FUNCTION BEING EXECUTED	ITIN	
25	EFFECTIVE PARAMETERS BEING SOLVED FOR (NUMB(11)-(NO. OF CONSTRAINTS))	CHAIN -	KNST
26	TAPE UNIT FOR GENERATING BCD STATION AND OBSERVATION TAPE (IF ZERO, NO TAPE GENERATED)	CHAIN -	ETAPE

Table 16 (cont.)

27	FLOCKS OF DATA	TRAIN
28	TAPE UNIT FOR ECLIPSE COORD TAPE	CHAIN
29	CURRENT PASS THRU DUM - 0 FOR 1ST PASS, 1 FOR REST	CHAIN
30	ELEMENTS IN ATA	MAIN
31	TAPE UNIT FOR NOMINAL TRAJ. FOR DIFFERENCING RUN	INPAL - NTAPE
32	TAPE UNIT FOR DIFFERENCED TRAJ. FOR DIFFERENCING RUN (LOGICAL NO.)	INPAL - DTAPE
33	MAXIMUM NUMBER OF 2ND DIFFERENCE EDITOR ITERATIONS	
34	NUMBER OF 3 COLUMN PARAMETERS	
35	}	
36		
37		
38		
39		
40		
41		
42		
43	CONVERSION CONSTANT FOR DISTANCES GENERATED IN GAIN. MUST BE INPUT = 3443.9336 NM/ER OR 6975.246 KYD/ER	
44	LOGICAL TAPE NUMBER FOR ANOTHER COMPACTED DATA TAPE TO BE GENERATED IN TRAIN	
	INDICATOR FOR FIXED BASELINE STATION LOCATION CONSTRAINTS - 1 IF OPTION BEING USED	
45	NOT USED	
46	NON-ZERO INDICATES SPECIAL TRAJECTORY TAPE GENERATION	TTAPE
47-50	NOT USED	

Table 17. IFLAG ARRAY

IFLAG - OPTION INDICATORS	INPUT NAME
1 CURRENT FUNCTION BEING EXECUTED = 1, } ORBIT DETERMINATION = 2, } = 3, TRAJECTORY = 4, GAIN	
2 RESTORE (1) LAST GOOD SOLUTION OR CORRECT (0) PRESENT SOLUTION 3 CURRENT LINK BEING EXECUTED 4 REASON FOR EXIT FROM MAIN (1-MAXIMUM NUMBER OF ITERATIONS. 2-CONVERGED, 3-TRAJECTORY COMPLETED)	
5 CORRECTIONS ARE HITTING BOUNDS (1) OR NOT (0) 6 = 0, COMPLETE SIGHTING EPHEMERIS PRINTED = 1, ONLY RISE, SET, MAXIMUM ELEVATION TIMES PRINTED = 2, ALL DATA, EXCEPT THAT AT RISE, SET, ETC., SAVED ON TAPE 7 ZERO, REGULAR RESIDUAL PRINTING NEGATIVE, AT ITERATION = MAXIT, SORTED RESIDUALS ARE PRINTED AFTER THE REGULAR RESIDUAL PRINTING POSITIVE, AT ITERATION = MAXIT, ONLY SORTED RESIDUALS ARE PRINTED. NO RESIDUALS ARE PRINTED PRIOR TO THIS. USED ONLY WHEN RESIDUAL PRINTING INDICATED IN THE PRCDE. (PRCDE(2))	PARTL
8 ANALYTIC TRAJECTORY PARTIALS (0) OR VARIATIONAL EQUATIONS (1) 9 BOUNDS PROVIDED FOR LEAST SQUARES SOLUTION (1) OR NO BOUNDS (0) 10 NOT USED	TMATX
11 T-MATRIX OPTION IF=0, NO T-MATRIX =1, INPUT DRHODH*H/RHO, NO EARTH FLATTENING =2, INPUT DRHODH*H/RHO, USE EARTH FLATTENING =3, CALC. DRHODH*H/RHO, NO EARTH FLATTENING =4, CALC. DRHODH*H/RHO, USE EARTH FLATTENING	ITIN
12 PARAMETER SPECIFYING SEQUENCE OF FUNCTIONS TO BE 13 PERFORMED 14 USED IN GAIN. IF = 0, SORT OUTPUT -- NON-ZERO, DO NOT SORT USED IN SUBROUTINE FINTR IN MAIN	IDIFF
15 TRAJECTORY COMPARISON OPTION IF IDIFF = 0, REGULAR TRAJECTORY = 1, WRITE PRESENT TRAJECTORY AS REFERENCE ON NTAPE = 2, 1ST COMPARISON, DIFFERENCES WRITTEN ON DTAPE	

Table 17 (cont.)

	= 3, OTHER THAN FIRST OR LAST COMPARISON CASES	
	= 4, FOR ONE AND ONLY COMPARISON CASE	
	= 5, LAST COMPARISON	
16	FORTRAN LOGICAL UNIT FOR TRAJECTORY TAPE WRITTEN BY FIT A AND GAIN A.	
17	SET NON-ZERO IN TSET IF TO IS A PARAMETER	
18	NON-ZERO, ACCUMULATE ATA IN DOUBLE PRECISION (FOR ATA LESS THAN 2746)	
19	IF SET NON-ZERO SIGMA TABLE WEIGHTING VALUES WILL BE USED EVEN IF VARIANCE/COVARIANCE MATRICES ARE INCLUDED IN DATA DECK	
20	IF NON-ZERO, OPERATE IN 3 PTS./PASS MODE	
21	OPTION INDICATOR FOR 2ND DIFFERENCE EDITOR, CONTROLS EDITING OF FIRST 2 AND LAST 2 POINTS	
22	} NOT USED	
23		
24		
25	SET IN TSET IF ALPHA PARTIALS ARE TO BE COMPUTED.	
26	AFTER COMPLETING FIT A CALL FIT B (0) OR DO NEXT FUNCTION (1).	
27	NOT USED	
28	INDICATOR FOR RESPECIFICATION OF GEOPOTENTIAL COEFFICIENTS \emptyset = RESPECIFICATION	
29	NUMBER OF ORBIT ADJUSTS IN SPECIAL TABLE (DELV)	IDLV

Table 18. CNDT ARRAY

CNDT - PARAMETER LIST. CODES ARE IN ITRCD

1-6	INITIAL CONDITIONS	
7	T-ZERO	
8	CDA/W	
9	GM	
10-18	J2-J10	
19-38	J21-J66	ORDERED J21, J31, J41, ..., J56, J66
39-58	LAMBDA21-LAMBDA66	SAME
59	ASUBE ' EARTH RADIUS	
60	OMEGASUBA - ATMOSPHERE ROTATION RATE	
61	T1 THRUST (T1*EXP(-T2*T))	
62	T2	
68-75	ICS, TO, AND DRAG FOR SATELLITE NO. 2	
80-87	ICS, TO, AND DRAG FOR SATELLITE NO. 3	
92-99	ICS, TO, AND DRAG FOR SATELLITE NO. 4	
104-111	ICS, TO, AND DRAG FOR SATELLITE NO. 5	
116-123	ICS, TO, AND DRAG FOR SATELLITE NO. 6	
124-129	NOT USED	
130-135		
136-153		
154	K-ZERO -- TELEMETRY DATA	
155	K-ONE -- TELEMETRY DATA	

Table 19. KIND ARRAY

KIND - - MISCELLANEOUS FIXED POINT INPUT		INPUT NAME
1	UNIT FOR INPUT BCD RADAR DATA TAPE	IBCDI
2	UNIT FOR INPUT BINARY COMPACTED RADAR DATA TAPE	IBINI
3	USED INTERNALLY	
4	EPOCH DATE - YEAR	YEAR
5	- MONTH	MONTH
6	- DAY	DAY
7	PRCDE - OUTPUT CONTROL	PRCDE
8	PARAMETER	
9	FLOCK FLAG	

Table 20. TREG ARRAY

USE OF TREG FOR INTEGRATION (COW)

TREG	CELL	CONTENTS
(K+3)		NEQ (SET IN COW AT B = 35)
(K+2)		CURRENT TIME IN MINUTES FROM MIDNIGHT OF EPOCH
(K+1)		CURRENT INTEGRATION STEP SIZE
(K)-(K-2)		X
(K-3I)-(K-3I-2)		X(PI)
(K-NEQ)-(K-NEQ-2)		X-DOT
(K-NEQ-3I)-(K-NEQ-3I-2)		X-DOT(PI)
(K-2NEQ)-(K-2NEQ-2)		X-DBL. DOT
(K-2NEQ-3I)-(K-2NEQ-3I-2)		X-DBL. DOT(PI)

WHERE ---- NEQ = 3(N+1)

N = TOTAL NUMBER OF I.C. AND D. E. PARAMETERS FOR THE CURRENT RUN

K = L-3 (CURRENTLY = 5490)

L = DIMENSION OF TREG = 90(M+1)+3

M = MAXIMUM NUMBER OF I.C. AND D.E. PARAMETERS (CURRENTLY = 60)

USE OF TEMP FOR INTEGRATION (DAUX AND PERT)

185.

Table 21 (cont.)

(658-677)	SIN(M(LAMBDA-LAMBDA(MN)))	GRAV CALLING SEQUENCE
(678-697)	COS(M(LAMBDA-LAMBDA(MN)))	GRAV CALLING SEQUENCE
(698-706)	DFDX(1) V-MATRIX	
(707-715)	DFDX(2) T-MATRIX	
(716-724)	DFDXD U-MATRIX	
(725-727)	DF/DX*(PSI(PK))	
(728-730)	DF/DXDOT*(PSI-DOT(PK))	
(731-910)	DF/DB	
(916)	RHO (DENSITY)	
(917)	A (VEL OF SOUND)	
(918)	H (ALTITUDE)	
(919)		
(920)	M (MACH NUMBER)	
(921-923)	X-DOT(A)	
(924)	D/V(A) = $\text{RHO}/2 * V(A) * \text{CDA}/W$	
(925-927)	F(3)	
(928)	ABSF(X-DOT) = V(A)	
(935-937)	F(4) THRUST FORCE	
(938-943)	ABSF(X(J))**3	
(944-949)	ABSF(X-X(J))	
(950-955)	ABSF(X-X(J))**3	
(956-961)	ABSF(X-X(J))**5	
(962-964)	X-X(1)	
(965-967)	X-X(2)	
(968-970)	X-X(3)	
(971-973)	X-X(4)	
(974-976)	X-X(5)	
(977-979)	X-X(6)	
(980-982)	F(2)	
(983-1000)	INTERPOLATED VELOCITIES OF OTHER BODIES	

Table 22. STAT ARRAY

STAT--PROPERTIES RELATED TO THE LTH STATION

CELL	DESCRIPTION	UNITS
(1,L) ---	GEODETIC LATITUDE	(RADIAN)
(2,L) ---	EAST LONGITUDE	(RADIAN)
(3,L) ---	ALTITUDE	(EARTH RADII)
(4,L) ---	COS (LAT)	
(5,L) ---	SIN (LAT)	
(6,L) ---	W1	(EARTH RADII)
(7,L) ---	W3	(EARTH RADII)
(8,L) ---	SIGMA SET	
(9,L) ---	REFRACTIVITY TYPE	
(10,L) ---	STATION NAME	
	Q STATION NUMBER	
	P STATION NUMBER	
(11,L) ---	(NOT USED)	

Table 23. COMMON LAYOUT

COMMON A - BLOCKS NEEDED FOR ALL LINKS - 8722 CELLS

ALPH	1	ITEMP	45
AUS	1	ITRCD	62
C	100	KIND	10
CC	3,6	NUMB	50
CO	56	PARINT	50
CI	56	PKICK	50
CNDT	160	PRTIM	21
CPRAM	2	PUSH	200
DAVE	100	REFR	15
DPRAM	40	SIS	1
DRAG	120	SUSP	1
ELL	20	TRAJX	367
FIC	10	TRJN1	552
FLEE	100	TUMP	100
HEAD	24	XTPA	50
IDTAPE	17	TEMP	1000
IFLAG	30	TREG	5493

COMMON B - BLOCKS NEEDED FOR FIT AND DATA GENERATION LINKS - 4300 CELLS

GOK	1800	PBIAS	100
BIAS	100	RPRAM	200
DPAR	100	SIGGY	100
ICDLC	100	SIGMY	100
IPRCD	500	STAT	11,100
ISIG	100		

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13. ABSTRACT This report describes the MITRE version of the TRACE-D program now in operation. While the primary function of TRACE-D is orbit determination, options are also available in the program for trajectory prediction and observational data generation. A functional description of these features is contained in this report along with a complete user's manual and a brief program description.			

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